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LEVEL III

FINAL SURVEY STUDY for GREAT LAKES and ST. LAWRENCE SEAWAY NAVIGATION SEASON EXTENSION.

VOLUME II.

APPENDIXES A - B.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the Final Report for the Great Lakes and St. Lawrence Seaway Navigation Season Extension feasibility study. The goal of this study is to consider the feasibility of means of extending the navigation season on the entire system from mid-December to early April (year-round). The report uses, as a base condition, the Chief of Engineers 16 November 1977 report which recommends the extension of the navigation season on the upper four Great Lakes to 31 January (+ 2 weeks). The purpose of this study is to determine whether

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Federal participation in Navigation Season Extension is desirable, and its extent, if any, to address the significant social, environmental, economic, engineering, and institutional aspects, and, to make a recommendation for Congressional consideration based on these findings.

This Final Report evaluates six proposals, considering various season lengths and geographic coverages, to further extend the navigation season on the entire Great Lakes/St. Lawrence Seaway System up to 12 months on the upper four Great Lakes, and up to 11 months on the Welland Canal, Lake Ontario and the International Section of the St. Lawrence River. This report relates U. S. costs to U. S. Benefits.

This study concludes that season extension is engineeringly and economically feasible year-round on the upper three Great Lakes, up to year-round on the St. Clair River-Lake St. Clair-Detroit River System and Lake Erie, and up to 10 months on Lake Ontario and the International Section of the St. Lawrence River. It is recognized that formal agreement with the Government of Canada is required for any extension on the system beyond the upper three Great Lakes. To assure and to confirm environmental and social feasibility of this program, an Environmental Plan of Action (EPOS) would be accomplished concurrently with implementation and execution of post-authorization planning, engineering, construction and operations with provisions to modify or stop the program if unacceptable environmental impacts surface. The District Engineer recommends that the project, as described above, be implemented.

This volume covers appendix A and B - problem identification and formulation of detailed plans.

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GREAT LAKES and ST. LAWRENCE SEAWAY

NAVIGATION SEASON EXTENSION

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AUGUST 1979
U.S. ARMY ENGINEER DISTRICT, DETROIT
CORPS OF ENGINEERS
DETROIT, MICHIGAN

APPENDIX A

PROBLEM IDENTIFICATION

AUGUST 1979

APPENDIX A

PROBLEM IDENTIFICATION

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APPENDIX A

PROBLEM IDENTIFICATION

INTRODUCTION

Major physical problem areas associated with winter navigation on the Great Lakes and St. Lawrence Seaway system involve four principal water navigation areas: (1) navigation channels, both interlake and on the St. Lawrence River, (2) harbors, (3) locks, and (4) open lake courses. They are affected by a wide variety of icing conditions. Ice in the connecting channels and river channels severely limits vessel movements, especially at channel bends in restricted areas and where ice booms have been placed to control ice movement. Icing at harbor entrances, in harbor turning basins, in channels, and at vessel berthing and docking areas hampers vessel maneuverability. Ice interference with lock operations is a major problem. Open lake ice and ice in the connecting channels presents a danger to shipping because of the possibility of structural damage to vessel hulls.

In addition, there are significant associated areas of concern. These are: (1) shore erosion and shore structure damage, (2) island transportation, (3) safety and survival, (4) the effect on personnel operating the vessels and locks, (5) movement of oil and other hazardous substances, (6) the possibility of unforeseen effects of winter navigation on hydro-electric power generation, (7) the potential of effects of winter navigation on the water levels and flows, (8) the liability aspects of winter navigation, (9) the international aspects of winter navigation, (10) high insurance rates, and (11) the elimination or mitigation of environmental damages, and/or compensation for the unavoidable resultant damages.

CANADIAN CO-PARTICIPATION

Canadian interest in the Navigation Season Extension Program has been demonstrated in several ways. A Canadian observer has been represented on the Winter Navigation Board since its inception. The Canadian Coast Guard and United States Coast Guard have prepared and distributed Joint Icebreaking Agreements for the past several years, resulting in Canadian icebreaking support for participating vessels. Canadian vessels have been sailing during past extended seasons under the Demonstration Program in significant numbers. Thirteen Canadian companies sailed 62 vessels during the 1977-78 extended season. The St. Lawrence Seaway Authority of Canada has undertaken a number of improvements in Canadian reaches of the St. Lawrence River which have enhanced shipping operations during mid-December and early spring periods.

Formal Canadian co-participation does not yet exist. Further coordination with Canadian agencies may be initiated upon signal from the Congress, such as passage of some new season extension authorization or when determined propitious by the Administration. A precise date for such actions cannot yet be determined, but the beginning of operations on International portions of the system would depend on consultation with the Canadians.

PHYSICAL SETTING

While existing Federal legislation does not prohibit system-wide winter navigation, the Great Lakes-St. Lawrence Seaway System has traditionally been closed to navigation or forborne by shippers from about mid-December until early April. However, a long history of localized, intralake winter navigation does exist in some areas. The physical description of the region tributary to the Great Lakes-St. Lawrence River system, along with general ice conditions and ice

problems experienced prior to the Demonstration Program, are given in the following paragraphs. Significant environmental effects, both favorable and unfavorable, of implementing the navigation season extension program, are addressed in Appendix F, Environmental.

Description of the Great Lakes-St. Lawrence Seaway System

The Great Lakes-St. Lawrence Seaway system shown on Figure 1 extends from the westerly end of Lake Superior to the Gulf of St. Lawrence on the Atlantic Ocean, a distance of more than 2,000 miles. The five Great Lakes...Superior, Michigan, Huron, Erie and Ontario, with their connecting rivers and Lake St. Clair, have a water surface area of about 95,000 square miles. The lakes lie partly within both the United States and Canada except for Lake Michigan, which lies wholly within the United States. The total area of the Great Lakes Basin, both land and water, above the easterly end of Lake Ontario is approximately 296,000 square miles, of which 174,000 square miles are in the United States and 122,000 square miles are in Canada. Table 1 displays descriptive data on the Great Lakes. The Great Lakes and their connecting channels have a controlling navigation depth of 27 feet (Figure 2).

In this climatic zone, where the period of freezing temperatures is normally not long enough to cause a lake-wide ice sheet to form, the stages of ice formation and melting sometimes go on simultaneously at different points. The effects of winds, currents, and upwelling upon the ice-cover cause rapid changes, making predictions of ice thickness and distribution difficult.

There are two general types of ice-cover that are formed on the Great Lakes: ice formed by the rapid freezing of surface water in the absence of wind and snow, called sheet ice; and ice made of fused individual ice pieces, generally referred to as agglomeratic ice.

GREAT LAKES BASIN

GREAT LAKES & ST. LAWRENCE SEAWAY SYSTEM
NAVIGATION SEASON EXTENSION PROGRAM

FIGURE 1

TABLE 1

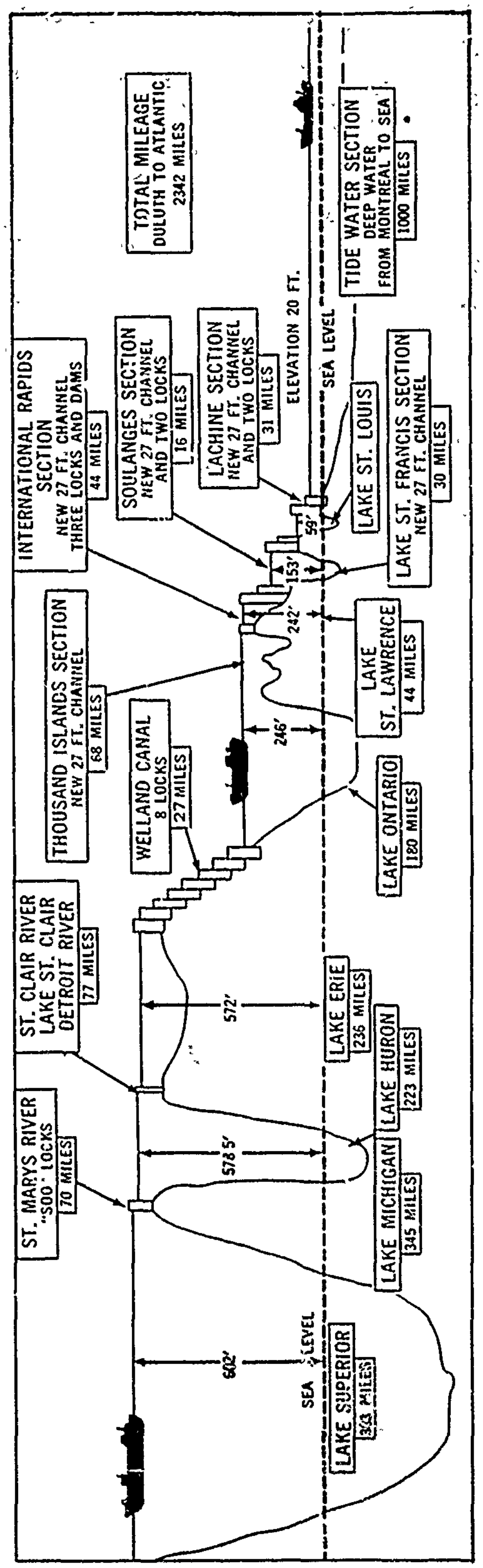
DESCRIPTIVE DATA ON THE GREAT LAKES

	Lake Superior	Lake Michigan	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario
Water Surface Area, Sq. Miles	31,700	22,300	23,000	400	9,900	7,600
Drainage Basin Area, Sq. Miles	81,000	67,900	74,800	6,500	33,500	34,800*
Maximum Natural Depth, Feet	1,333	925	752	21**	212	804
Average Natural Depth, Feet	489	279	195	10	62	233
Length, Miles	350	307	206	26	241	193
Breadth, Miles	160	118	101	24	57	53
Water Volume, Cubic Miles	2,935	1,180	849	1	116	393
I.G.L.D. Elevation***	600.0	576.8	576.8	571.7	568.6	242.8

*Includes water surface area and tributary land area downstream to the St. Lawrence Power Project at Cornwall.

**The depth of the navigation channel traversing Lake St. Clair is 27.5 feet. It is commonly referred to as part of the St. Clair-Lake St. Clair-Detroit River connecting channel system.

***International Great Lakes Datum (1955), Low Water Datum or Chart Datum.



GREAT LAKES - ST. LAWRENCE SEAWAY PROFILE

FIGURE 2

Agglomeratic ice usually contains ice of various ages combined with snow masses that have been welded together by new lake ice and is formed when warm weather allows the breakup of thin, young sheet ice.

Ice-cover on the lakes first occurs in the sheltered bays and harbors and in a narrow fringe along the shoreline. The effects of winds, currents, and upwelling upon the ice-cover causes it to change rapidly because long fetches across the lake surfaces allow the wind and wave forces to attain considerable strength. As the ice-cover moves and changes, it rafts and forms ridges that in some areas reach a height of 25 feet. Lake ice thickness normally varies from a few inches to three feet or more in protected areas.

Ship traffic between Lakes Superior and Huron is halted with the seasonal closing of the Soo Locks. Similarly, navigation stops between Lakes Erie, Ontario, and the Atlantic Ocean with the closing of the Welland Canal and St. Lawrence Seaway.

Some navigation does continue year-round in localized areas and is only halted during the most severe winter conditions. For many years automobile and railroad car ferries have operated across Lake Michigan between ports in Michigan and Wisconsin. Railroad ferries operate across the Straits of Mackinac, the St. Clair River and also the Detroit River. Car ferries operate in the St. Marys and St. Clair Rivers. There are daily tug-barge fuel deliveries between Sarnia, Ontario, on the St. Clair River and power plants on the Detroit River. Similarly, coal deliveries continue between Toledo, Ohio, in western Lake Erie and power plants along the Detroit River.

There have also been instances at the Soo Locks, prior to the Navigation Season Extension Program, of transit being continued into the winter beyond the traditional closing of mid-December. Under extraordinary circumstances, such as strikes in the steel industry during 1956 and 1959, or at times of national emergency, such as

December 1944-January 1945, lock operations were maintained to accommodate urgent shipping needs. Regulations have been in existence at the Soo to permit such action when authorized by the Division Engineer. During the period 1965-1970, the Lake Carriers' Association requested each season to have lock operations continued into late December and then January. These requests were approved. By the 1970 season, for instance, shipping in the winter continued through January 29, 1971, which permitted 152 transits to be made through the locks after the traditional closing date. As a result, 1,423,612 net tons of additional cargo were shipped, consisting primarily of iron ore and grain. This amount was roughly equivalent to the tonnage moved over an average three day period at midseason. In this way, a modest expansion of the shipping season was already resulting in increased winter transit activity at the Soo prior to 1971 and the introduction of the Navigation Season Extension Demonstration Program.

Prior to the Navigation Season Extension program, Coast Guard vessels were generally engaged in icebreaking activities in early winter and spring, primarily to assist in keeping navigation channels open for vessels operating in ice conditions prior to and immediately following winter lay-up. This is consistent with the 1936 Executive Order to the Coast Guard directing "the Coast Guard to assist in keeping open to navigation by means of icebreaking operations, insofar as practicable and as the exigencies may require, channels and harbors, in accordance with the reasonable demands of commerce."

An important part of Coast Guard winter support operations preceding the Navigation Season Extension Program was the establishment of command areas in the upper four Great Lakes. Designated as Coal Shovel, Oil Can, and Taconite Commands, these organizational structures served to facilitate communications between the Coast Guard, home port offices, and vessels on the lakes, and to coordinate icebreaking resources in the most effective manner.

Operation Coal Shovel continues to cover Lake Erie, the Detroit River-Lake St. Clair-St. Clair River, and south and central portions of Lake Huron. Operation Oil Can covers Lake Michigan, and the Taconite Command is concerned with the southern half of Lake Superior and the northernmost portion of Lake Huron.

Search and rescue missions on the Great Lakes during winter months consisted almost entirely of individual incidents related to ice, such as rescuing fishermen adrift on ice floes and persons falling through thin ice in harbors and bays.

Navigational aids within the major rivers and harbors, particularly lighted buoys and radar reflector unlighted buoys, are removed by the Coast Guard during late November and December to prevent damage and/or loss caused by winter ice. Some of these were replaced with smaller, unlighted buoys that were subject to being submerged or carried off station by moving ice.

Winter data collection relating to overall ice conditions and dissemination to shippers did not exist. Local ice information was relayed upon request by local Coast Guard and harbor master installations. Weather forecasts for the open waters (more than five miles from shore) were discontinued during the winter season. The season was formally opened and closed each year after consultation between the various National Weather Service units involved and the Lake Carriers' Association. A limited forecasting service for small areas which had car ferry or fishing activities was continued through the winter. A forecast for the opening of navigation was released by mail on the first Monday in March, and updated each subsequent Monday until all significant ice was gone.

Lake Superior (Figure 3) is the largest of the lakes, with a length of 350 miles and a maximum width of 160 miles. Compared with the other Great Lakes, its surface is more elevated above the sea

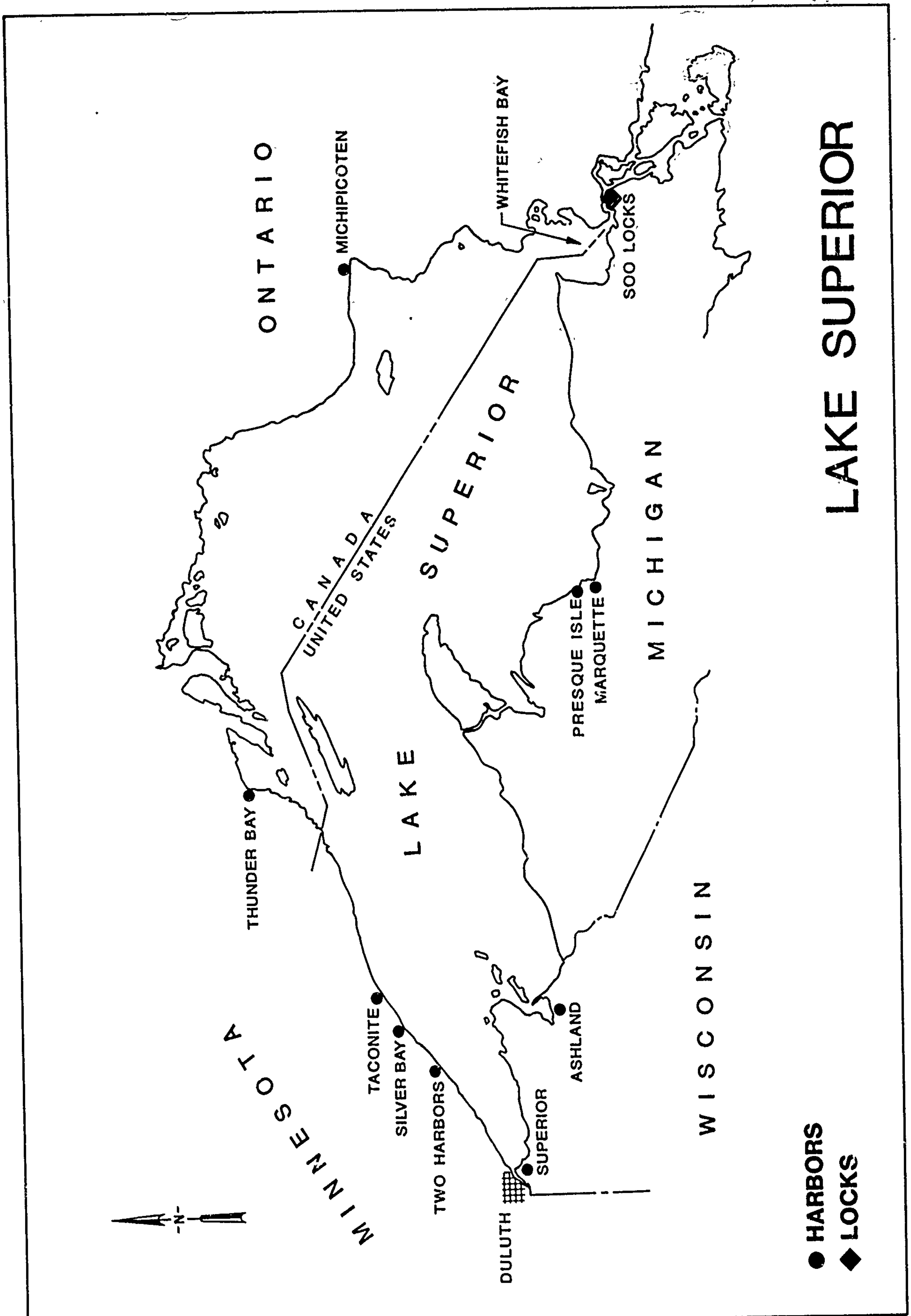

LAKE SUPERIOR
ONTARIO
MICHIPICOTEN
WHITEFISH BAY
SOO LOCKS
CANADA
UNITED STATES
LAKE SUPERIOR
MICHIGAN
PRESQUE ISLE
MARQUETTE
THUNDER BAY
MINNESOTA
TACONITE
SILVER BAY
TWO HARBORS
DULUTH
SUPERIOR
ASHLAND
WISCONSIN
N
● HARBORS
◆ LOCKS

FIGURE 3

(600 feet), is more irregular in outline, has deeper water (maximum depth 1,333 feet), more fog, more sheet ice, and less rain.

This lake has a large heat storage capacity; hence, winds, waves, and currents, acting together with the stored heat energy, have a pronounced effect upon the ice-cover. Upwelling currents change the extent and distribution, and cause melting wherever they come in contact with the ice-cover, even though air temperatures are below freezing.

Under normal climatic conditions, the period of ice formation begins in January and continues to maximum accumulation about the last week of March. The northern location and the ice season duration give Lake Superior the thickest ice-cover of all the Great Lakes. Ice thicknesses in excess of 40 inches are common in many harbors along the north shore. The composition of the ice-cover ranges from fast, thick, winter ice and areas of consolidated young ice and pancake, to vast areas of pack ice made up of fields and floes of drifting brash and cake ice.

There are seven major U.S. harbors located in Lake Superior as shown in Figure 3, underlined, and described below.

Taconite Harbor, Minnesota, is located just northeast of Two Harbors, Minnesota and about 76 miles northeast of Duluth, Minnesota. The harbor is privately owned and maintained by the Erie Mining Company and is used primarily to ship out taconite pellets and ship in coal (by that company). The harbor has two entrances. Prevailing westerly winds and a northeast shore current tend to flush harbor ice out of the eastern entrance and keeps the harbor area open much of the winter. Ice thickness rarely exceeds four inches in the harbor and docking areas. Year round navigation has occurred since 1973-74 at this harbor, except for a brief period in 1977.

Silver Bay, Minnesota, is located about 55 miles northeast of Duluth, Minnesota. It is a private harbor, owned and maintained by Reserve Mining Company and used primarily to ship out taconite pellets and ship in coal. The harbor and surrounding area remains open most of the winter. Predominant winds drive lake ice offshore for several miles. Ice thickness can reach 14 inches but rarely exceeds six inches in the harbor and docking areas. To date, the harbor has not operated on a year round basis.

Two Harbors, Minnesota, is located on Agate Bay, a natural indentation about 3/4 mile long and 1/2 mile wide on the northwestern shore of Lake Superior. Iron ore and taconite are the major products shipped from this harbor. Predominant northwesterly winds tend to blow lake ice away from the harbor which keeps the entrance area ice-free most of the winter. Before year round navigation started in 1974-75, the harbor closed for the winter and ice thicknesses along the north face of the ore docks would develop to a depth of 24 to 30 inches.

Duluth-Superior Harbor is located on the border between Minnesota and Wisconsin at the extreme western end of Lake Superior. The extensive dock facilities and magnitude of commerce make the harbor one of the most important on the Great Lakes and in the Nation. While providing excellent protection from summer storms, it is a rather poor winter harbor. Its shallow depth and the prevailing cold temperatures foster rapid ice growth that can reach a thickness of 30 inches. In addition, the adjacent lake area is subject to wind blown rafting that can extend out from the harbor for several miles. At present, the harbor does not normally operate later than mid-January because of severe winter conditions.

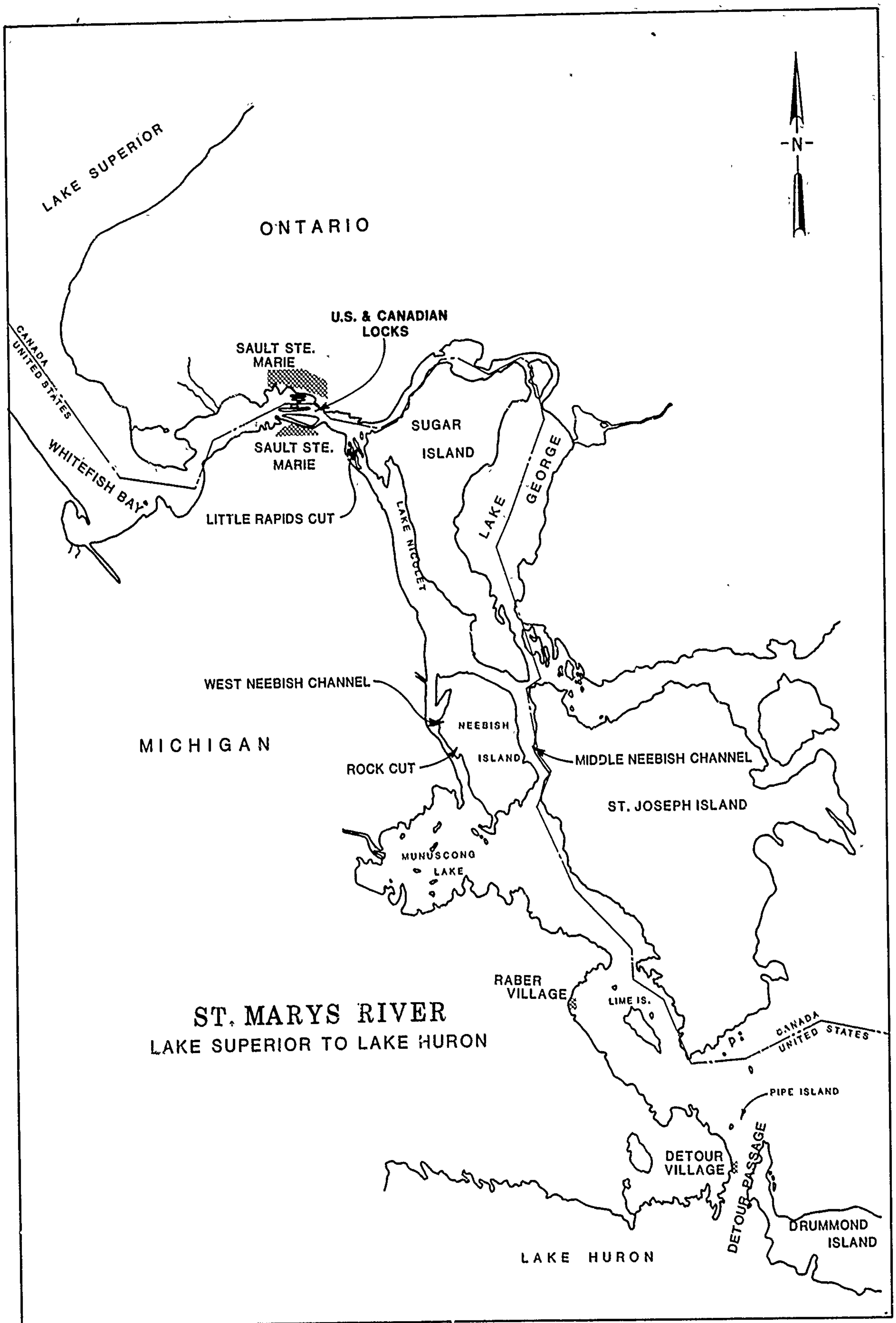
Ashland Harbor, Wisconsin, is located about 60 miles east of Superior-Duluth Harbor. The harbor is in a relatively well protected, shallow bay. Ashland experiences the coldest weather of

any harbor on the Great Lakes and consequently develops a very heavy ice and snow cover that remains until late spring. Normally the harbor is closed in winter. During the regular season the harbor primarily receives coal for the local power plant. Limestone is the only outgoing commodity.

Presque Isle Harbor, Michigan, is located on the south shore of Lake Superior about three miles north of Marquette, Michigan. The harbor is well protected from prevailing northwesterly winds by Presque Isle Point. Major commodities shipped during the regular season are incoming coal and outgoing taconite pellets. At present, the harbor is closed from mid-December to early April. Ice thickness may reach 30 inches in the harbor and dock areas. A level, stable ice cover generally exists in and around the harbor area throughout the winter.

Marquette Harbor, Michigan, is located on the south shore of Lake Superior adjacent to the City of Marquette. The harbor has a basin area of about 350 acres and is well protected by shoreline to the west and north and by a breakwater on the east. Major commodities shipped during the open water season include coal, lignite, slag, and local commodities (fish). Coal is primarily brought in for the city-owned steam generating plant, which is currently under expansion and is scheduled for completion in the latter part of 1981. Coal is stockpiled during the winter months of December through March. A level, stable ice cover, that rarely exceeds 2 feet in thickness, generally exists in and around the harbor area throughout the winter. A small area of open water is usually evident in the vicinity of the discharge from the power generating station.

St. Marys River: The St. Marys River, shown in Figure 4, is the only outlet of Lake Superior and water leaves the lake at Point Iroquois, flowing in a general southeasterly direction through several channels to Lake Huron, a distance of 63 to 75 miles,



ST. MARYS RIVER
LAKE SUPERIOR TO LAKE HURON

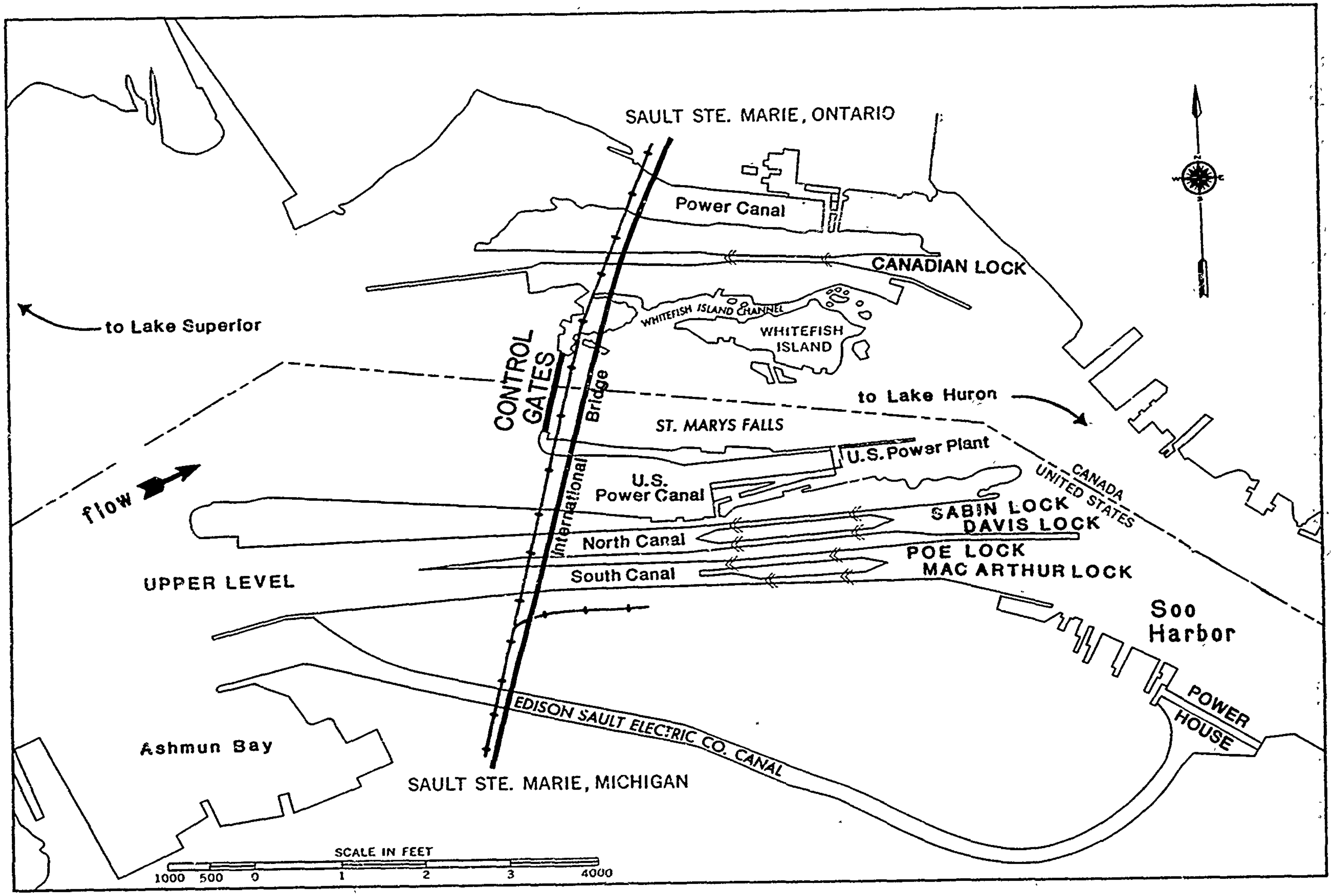
FIGURE 4

depending on the route traversed. Traditionally, navigation ceased about 15 December and did not resume until late March or early April. The Division Engineer, North Central Division, Corps of Engineers, makes the decision as to when the Soo Locks will be closed to navigation, based on reasonable demands of commerce. Winter months are used to dewater and perform regular maintenance on the lock facilities.

Shifting ice fields occur naturally in Whitefish Bay and Detour Passage as a result of changing wind and weather conditions. With navigation ceasing in mid-December, shipping experienced little difficulty in transiting these areas unless there was an early winter freeze. In the Detour Passage area, floe ice is frequently blown from Lake Huron into the Passage area in the vicinity of the Drummond Island ferry crossing, causing periodic problems to ferry operations.

Flow through the St. Marys River is completely controlled in the mile-long reach between the Cities of Sault Ste. Marie, Michigan and Ontario, shown in Figure 5. Originally this area was a series of rapids that held Lake Superior at an elevation about 21 feet higher than Soo Harbor. A combination of four U.S. locks, two U.S. power plants, one Canadian lock, and one Canadian power plant utilize a minimum flow of about 55,000 cubic feet per second (cfs) (See Table 2 for the principal features of the locks). Excess flow is discharged through a gated control structure located just upstream of the remaining rapids. The International Boundary bisects the 16-gate control structure. Each gate is 55 feet wide and lifts vertically between eight feet wide stone and masonry piers. A minimum of 1/2 gate open is maintained under low flow conditions for environmental reasons in the rapids area.

Flow through the lower St. Marys River has been completely regulated since 1921 by the International Lake Superior Board of Control. A controlling factor is the level of Lake Superior which,



ST. MARYS RIVER – VICINITY OF SAULT STE. MARIE, MICH –ONT.

FIGURE 5

Table 2
PRINCIPAL FEATURES OF LOCKS, ST. MARYS RIVER

Principal Features	MacArthur	Sabin	Lock Davis	Poe	Canadian
Width, feet	80	80	80	110	59
Length between mitre sills, feet	800	1350	1350	1200	900
Depth on upper mitre sill, feet	31	24.3	24.3	32	16.8
Depth on lower mitre sill, feet	31	23.1	23.1	32	16.8
Lift, feet	22	22	22	22	22

by International agreement, is not to exceed a maximum elevation of 602.0 feet, International Great Lakes Datum (IGLD 1955). Minimum elevation may vary, but generally is maintained about 600.0 feet IGLD.

Because of the difficulty in moving control gates during winter conditions, gates are generally pre-set prior to freeze-up to allow a constant outflow during the winter months based on predicted Lake Superior levels. Experience has also shown that flows in excess of 85,000 cfs have resulted in an unstable ice cover in Soo Harbor, causing ice jams to form in Little Rapids Cut. The control gates can be moved in winter, but require extensive steaming and chipping to loosen ice that forms in the gate guides. This is done only in emergency situations.

A principal problem in the Soo Harbor, prior to the Demonstration Program, was loss of power due to a reduction in operating hydraulic head (i.e. raising of the power plant tailwater level) caused by ice jams downstream in the Little Rapids Cut. In one instance, during December 1951, flooding caused damage along the St. Marys River and almost flooded the Edison Sault Plant. With the exception of the December 1951 incident, damage due to flooding has been prevented by emergency movement of gates in the compensating works.

Ice booms are placed at the head of the power canals upstream of the power plants to prevent ice from flowing in the power intakes structures. Periodically, ice would pass under the booms, particularly during the spring breakup period, and partially plug the grates of the intake structures. The fast velocity of the water would eventually erode the ice away on the grates.

The ice conditions immediately upstream of the lock gates had caused problems prior to the close of navigation in mid-December and early spring. Ice formed by early winter or that remaining at spring

opening was broken by wind, waves, current, or ship traffic and pushed and drawn into the lock entrance areas. Opening of the upper gates was restricted by ice packed in the lock approaches, often delaying the transit of vessels until gates could be fully opened. These problems were short-lived since the locks were closed for the main part of the ice season. Similar problems existed at the downstream lock entrance as harbor ice backed up to the lock gates or was packed into the area due to flushing of ice from the lock chambers.

The MacArthur Lock was normally dewatered from mid-December to 1 April and, therefore, no problem existed with ice removal from the lock. The larger Poe Lock, size 1,200 feet x 110 feet, was put into service in 1969 and has transited vessels for extended season navigation prior to the Demonstration Program. Vessel passages were slowed considerably by ice being pushed into the lock by the vessels, and often a separate locking action was required to remove ice from the lock chamber before a vessel could enter.

The collar of ice that formed around the lock walls between lockages was not a problem, as few vessels transited the locks during the winter season. Also, large width vessels were not in use, and the effect of crushed ice coating lock walls did not exist.

Increased wear and maintenance needs on the lock gates, valves, fender booms and related equipment have been noted during the short periods of ice operations prior to normal closing 15 December and after opening 1 April. Corps of Engineer floating plant equipment did not operate during the heavy ice conditions, 20 December to 25 March, and consequently did not encounter ice operation problems.

Ship traffic through the locks is controlled by the Chief Lockmaster on duty in the canal tower. Policy is that of first come, first served, unless extenuating circumstances prevent normal procedure.

Vessel traffic control was, and still is, provided by the U.S. Coast Guard in the St. Marys River to prevent collisions, rammings, and groundings and to expedite traffic movement.

Social problems involving lock operation personnel had normalized prior to the extended season. Personnel used the closed season 15 December to 1 April to make use of their annual leave (vacation) time. They also were not exposed to continuous extreme weather and hazardous working conditions. Also, diving operations were accomplished during the summer months with an occasional dive being required during lock lay-up and fitting out.

Of particular interest in the St. Marys River are the islands which are inhabited year-round, namely, Sugar, Neebish, Lime, and Drummond Islands. Regular access to these islands is by ferry or private boat during the open water period. Year-round ferry service is provided to Sugar and Drummond Islands. Winter access to Neebish and Lime Islands is over the ice when it is strong enough to support foot or snowmobile traffic.

Sugar Island, located just downstream of Soo Harbor, is about 15 miles long with a maximum width of 8-1/2 miles. The island has about 450 permanent residents. Travel to and from the island is by a single ferry with a capacity of 12 automobiles. During the winter season the ferry transports about 60 autos per day. In addition, the ferry transports the school buses for about 50 children attending schools on the mainland, as well as trucks supplying provisions and fuel oil to the island.

Prior to the extended navigation season, the ferry would suffer occasional disruption to service when wind or thaw conditions would break ice in Soo Harbor and temporarily fill the ferry track with ice.

Under normal winter conditions, thin ice generated in Soo Harbor would partially fill the Little Rapids Cut after Lake Nicolet became ice covered. As ice thickness increased, an ice bridge would form at the lower end of Soo Harbor, arching across the entrance to Little Rapids Cut, just upstream from the Sugar Island ferry crossing.

Current velocity and repeated ferry crossings would keep a narrow band of water open in this area throughout most of the winter, but when ice blockage would occasionally occur, the Coast Guard would undertake icebreaking until a new ferry track was re-established.

Neebish Island is about four miles long and two miles wide and is located just downstream from Sugar Island. It is bounded on the Canadian side by the upbound Middle Neebish Channel and on the United States side by the downbound West Neebish Channel. The island has a number of summer homes but has a small winter population of 30 to 50 residents.

The West Neebish Channel is about 9,000 feet long and 300 feet wide. About one mile of the channel is rectangular in shape and cut through rock, an area commonly called the Rock Cut.

Traditionally, any winter navigation is restricted to the Middle Neebish Channel. The U. S. Coast Guard announces when the West Neebish Channel will no longer be used, based on potential problems including those encountered by the Neebish Island ferry with early ice. Once the channel closed, since ferry service is discontinued, Island residents would travel back and forth on the ice just upstream and downstream of the Rock Cut Channel. Downbound ship traffic was diverted to the Middle Neebish Channel and controlled by the Coast Guard at Sault Ste. Marie until traffic stopped for the winter. Traffic control is necessary to allow only one-way traffic at any

given time. One problem with downbound loaded traffic in the Middle Neebish is the difficulty in negotiating the tight turns, particularly with one-half of the channel dredged to only 21 feet. Care must be taken by vessel operators to remain in the half of the channel dredged to 27 feet. Vessels also have less steerage control downbound than upbound because of the current.

Lime Island, located about 35 miles downstream from Sault Ste. Marie, is separated from the mainland by three miles of water. The activity on this U.S. island is the operation of a fueling station for freighters which stop during the regular season and general maintenance during the winter. About ten adults, employees and relatives of the company's employees, live on the island during the winter months to maintain the island facilities. Transportation to the island is by small tug boat during the regular navigation season, before the formation of heavy ice, and by foot or snowmobile after ice has formed. Island residents were without access to the mainland for a short time between the passing of the last commercial vessel and ice cover reaching sufficient thickness to safely carry pedestrians and snowmobiles in early winter and during the spring ice break-up period.

Drummond Island is located at the lower end of the St. Marys River where it enters Lake Huron. It is separated from the Michigan mainland by the mile-wide DeTour Passage. The island supports the Drummond Dolomite Quarry, summer recreational facilities, and about 600 permanent residents. One ferry operates on a regular schedule during the open water period and a second ferry is placed into operation during peak hunting and fishing seasons. The smaller ferry is capable of minor icebreaking and is utilized throughout the winter. Ferry traffic is occasionally disrupted by ice floes which jam in the Passage, particularly when Lake Huron ice is blown into the area by southerly winds. Wind also blows loose ice against the shoreline and into the ferry slips which occasionally hampers docking operations.

Shoreline erosion during the winter months did not appear to be a problem along the St. Marys River because of the frozen condition and ice armoring along the shoreline. Sediment transport continued, but at a reduced rate in most areas due to normally lower winter flow rates.

Disruption of the shoreline generally occurred during the spring break-up period. As the shoreline warmed with spring approaching, some shorefast ice would break away, tearing vegetation frozen in the ice, and causing some bottom scouring. Some ice would also dig into the shoreline and shallow bottom areas. Shore erosion is an all-season natural phenomena with many possible causative factors, including high water, natural spring breakup, and vessel wave wash. Definition of causative factors is very difficult without a site-by-site analysis over an entire year or several years.

There are numerous docks and shore structures adjacent to the navigation channel between Soo Harbor and Lake Munuscong (Lake Huron elevation). Disruption of shore structures would occur at any time during the winter months without navigation. As the shoreline warms with spring approaching, large quantities of ice move in mass in the river and damage some shore structures by the lateral forces generated by the moving ice. Shore structure damage would also occur when pilings, frozen in the ice, were lifted vertically by changing water levels.

Winter recreation includes primarily icefishing and snowmobiling on the ice along the St. Marys River. Without winter navigation, any disruption to these activities was only due to natural conditions, such as winds causing shifting ice conditions, periodic warm weather thaws, and spring breakup.

Prior to winter navigation, certain winter navigation stated problems did not exist or were considered minimal. These include bottom scour and ship induced turbidity, vibration of shore structures, maintaining vessel tracks in heavy ice fields, negotiating tight turns in ice clogged channels, and winter navigation disruption to wildlife migration. These and other problems will be discussed under extended navigation season conditions.

Lake Michigan: Lake Michigan (Figure 6), because of its north-south orientation and 300 mile length (118 miles maximum width), can have ice formation and deterioration simultaneously. The period of extensive ice formation begins about the last week of January and continues until around the third week of March. During a severe winter, ice may cover 100 percent of the surface. Generally, the northern half of the lake contains the heaviest ice concentration throughout the winter.

The circular surface current patterns of the southern basin distribute drifting floes along the shore, and even during a mild season, the drift ice is consolidated and can extend from shore out into the lake a distance of 10 to 15 miles. The distribution of ice, particularly pack ice, is primarily governed by wind and current patterns.

Some winter shipping occurs in the southern half of the lake with oil and petroleum product deliveries to Michigan and Wisconsin ports from refineries located near Chicago.

Lake Michigan and the Straits of Mackinac have a major network of railroad, freight, and auto ferry services. The greater part of this service stops during January, February and March.

The Ann Arbor R.R. and Auto Ferry will operate on an unscheduled basis during the winter across Lake Michigan between Frankfort, Michigan, and Kewaunee, Wisconsin, as conditions permit.

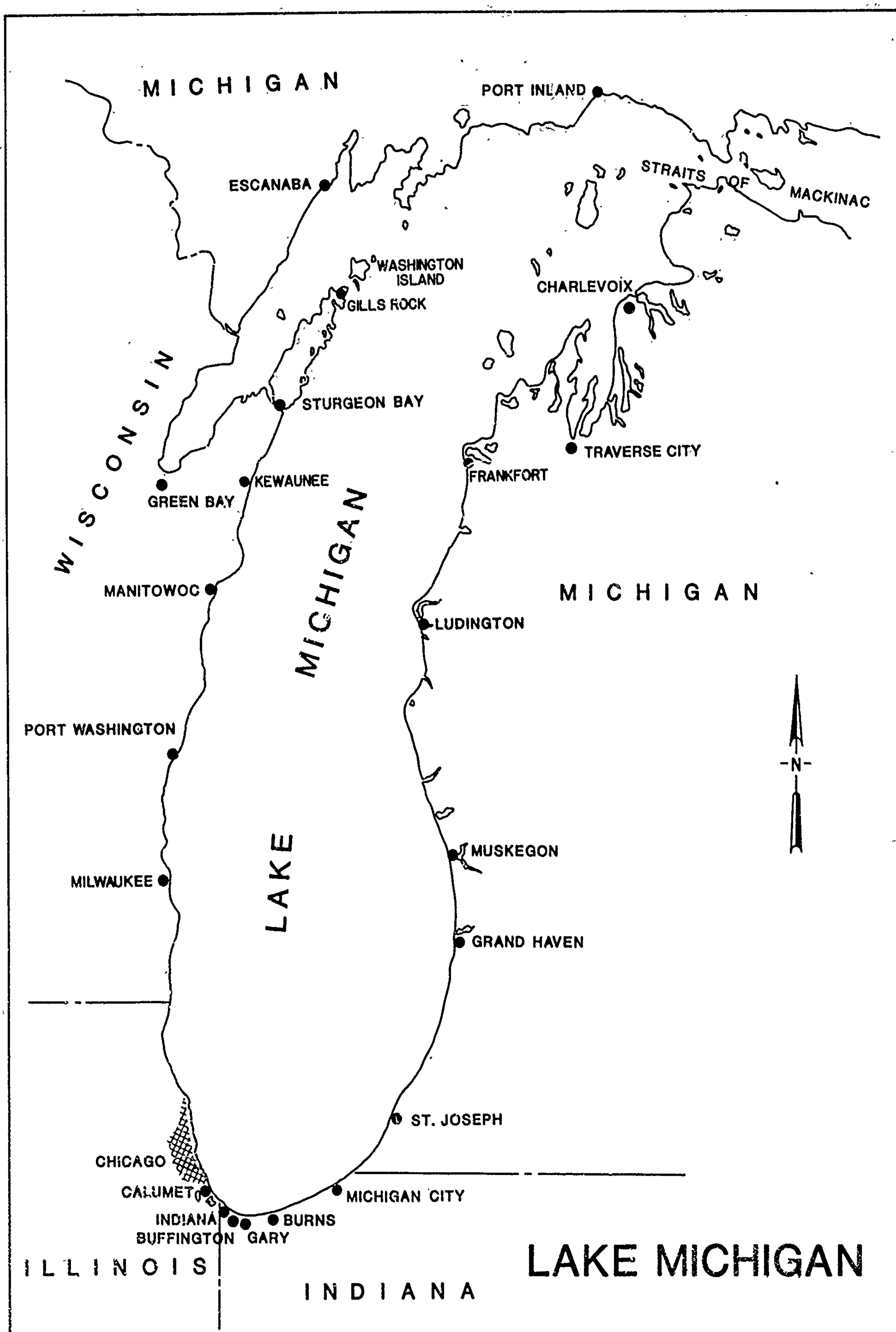

MICHIGAN
PORT INLAND
ESCANABA
STRAITS OF MACKINAC
WASHINGTON ISLAND
GILLS ROCK
CHARLEVOIX
WISCONSIN
STURGEON BAY
TRAVERSE CITY
FRANKFORT
KEWAUNEE
GREEN BAY
MICHIGAN
MANITOWOC
MICHIGAN
LUDINGTON
N
PORT WASHINGTON
LAKE
MUSKEGON
MILWAUKEE
GRAND HAVEN
ST. JOSEPH
CHICAGO
CALUMET
MICHIGAN CITY
INDIANA
BURNS
BUFFINGTON
GARY
ILLINOIS
INDIANA
LAKE MICHIGAN

FIGURE 6

The Chesapeake and Ohio R.R. and Auto Ferry provides unscheduled winter sailings across Lake Michigan between Ludington, Michigan, and both Manitowoc and Milwaukee, Wisconsin, as conditions permit.

A short-run ferry service between Gills Rock, Wisconsin, and Washington Island, Wisconsin, operates one ferry during the winter, when conditions permit.

Lake Michigan Harbors: There are 14 major harbors in Lake Michigan as shown and underlined in Figure 6, and described below.

Port Inland Harbor, Michigan, is a private harbor owned by the Inland Limestone Company. The harbor is located in northern Lake Michigan and is closed during the winter months. A stable ice cover up to two feet thick forms within the harbor. The area outside of the harbor is usually ice free due to prevailing winds which break up the ice as it forms and blows it south into the lake.

Escanaba Harbor, Michigan, is situated on the west shore of Little Bay de Noc in northern Lake Michigan. The harbor and bay usually freeze to a solid uniform ice cover reaching a thickness up to three feet. This condition generally remains stable throughout the winter. In spring, the entire ice sheet is usually blown south into the lake - sometimes in a single day.

Green Bay Harbor, Wisconsin, located along a 3.5 mile reach of the Fox River, has 37 docks which are used to ship a wide variety of products, including oil, soap, cement, and paper. Nav[illegible] usually ceases in mid-December and resumes in late March. Ice in the harbor and along the docks generally forms a uniform cover 18 to 24 inches thick. The main area of Green Bay is subject to ice ridges and windrowed ice from the predominant northwesterly winds throughout the

winter. The entrance to the harbor generally remains open because of a thermal discharge from the local sewage treatment plant.

Port Washington Harbor, Wisconsin, is located on the western shore about 29 miles north of Milwaukee. The harbor is usually ice free due to a thermal discharge from the local power plant. The area outside of the harbor is usually ice free due to the predominant offshore winds.

Milwaukee Harbor, Wisconsin, is a large port area which has traditionally been used by car ferries and local tankers throughout the winter. The predominant westerly winds tend to keep the western shore of Lake Michigan, including the harbor area, ice free most of the winter. Frequent ship traffic keeps a track open within the harbor where refrozen brash is generally less than six inches in thickness.

Chicago Harbor, Illinois, has both an outer and inner basin. A lock and control works allow access to the inner basin and the Chicago River and Chicago Sanitary and Ship Canal. The river and canal usually remain ice free throughout the winter. Ice conditions in southern Lake Michigan change rapidly with prevailing winds. Occasionally, ice pieces will pack up to 15-20 feet thick and extend 20-25 miles out from shore. This condition is transient and may last from a few hours to several days until winds shift or lessen in intensity.

Calumet Harbor, Illinois & Indiana, is located about 12 miles south of Chicago Harbor. Ice conditions in the lake are similar to Chicago Harbor. Wind blown ice will temporarily compact up to 20 feet and extend into the lake for miles until there is a shift or change in wind intensity. Ice in the Calumet River rarely exceeds six inches but may grow up to two feet thick in Lake Calumet.

Traditionally, there has been year-round barge traffic in the Calumet River and to southern Lake Michigan ports.

Indiana Harbor, Indiana, located about seven miles southeast of Calumet Harbor, consists of an inner and outer harbor. The entire harbor and canal is usually ice free due to a thermal discharge from Inland Steel. Ice conditions outside of the harbor are typical of southern Lake Michigan. Wind driven pack ice can extend into the lake for miles, lasting for periods of several hours to several days. This condition can occur several times throughout the winter.

Buffington Harbor, Indiana, is a private harbor owned by the Universal Cement Division of the U. S. Steel Corporation. Because this harbor handles limestone primarily, it does not normally operate during the winter period, mid-December to late March. Ice conditions at the harbor entrance are directly related to general ice conditions in southern Lake Michigan. On-shore winds will temporarily windrow ice up to 20 feet in depth that may extend up to 25 miles into the lake. The condition is transient and rarely lasts more than two days until winds shift and allows the pack to loosen or drift into the lake.

Gary Harbor, Indiana, is generally ice free most of the winter because of a thermal discharge from the local steel mills. The area outside of the harbor is subject to wind blown ice jams similar to those described above. These conditions average two days in January, four and one-half days in February and seven days in March with an average duration of one and one-half days and maximum duration of five days.

Burns Waterway Harbor, Indiana, normally is open year-round to tug-barge traffic. There are few ice problems in the harbor. Most problems occur in the lake with wind driven pack ice temporarily blocking the harbor until there is a shift in the wind. This condition usually lasts one to two days and occurs several times during the winter.

Grand Haven Harbor, Michigan, is located in the mouth and lower portion of the Grand River in southern Lake Michigan. During periods when pack ice is blowing towards shore, broken ice will enter the harbor and build to a thickness of three to eight feet, extending up to one mile into the harbor. Above this point, the ice cover is stable, reaching a thickness up to 18 inches. Depending on wind speed and duration, windrowed ice can jam up to 12 feet thick in the lake and harbor entrance. This problem is usually transient, but may persist from several hours to several days.

Muskegon Harbor, Michigan, is located in Muskegon Lake, just inland from Lake Michigan. Entrance into the harbor is through a 200-foot wide channel protected by breakwaters extending into Lake Michigan. Car ferry steamers traditionally operate between Milwaukee and Muskegon Harbors. The ice in Lake Muskegon is generally uniform, growing up to two feet thick outside of the navigation track. Ice conditions at the harbor entrance and into the lake are typical of other southern Lake Michigan areas. Wind driven ice may temporarily build up to 15 feet in thickness and extend into the lake for miles. A wind shift will usually clear the area or loosen the ice pack.

Ludington Harbor, Michigan, is located in Pere Marquette Lake just inland from the Lake Michigan shoreline. The outer basin in the lake is enclosed by two converging breakwaters. Car ferries traditionally operate year-round averaging four transits per day. Ice can grow to two feet thick in the harbor and connecting channel outside of the navigation track. Ice conditions at the harbor entrance are similar to other harbors in the area. Pack ice will be temporarily blown into windrows, extending for several miles into the lake, until winds shift and loosen the jam.

<u>Straits of Mackinac</u>: The Straits of Mackinac, shown in Figure 7, connect Lakes Michigan and Huron. The narrowest portion between the

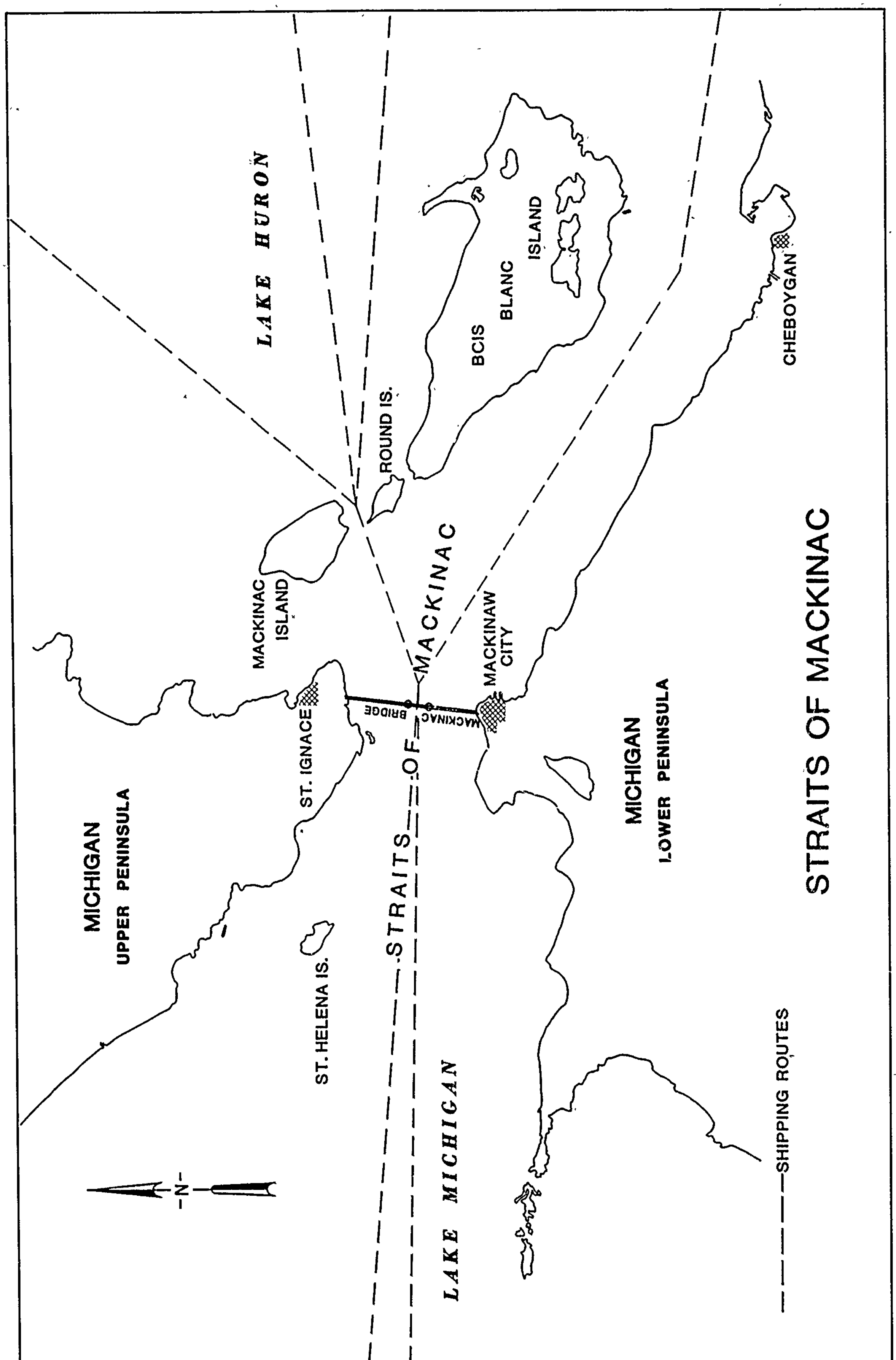

STRAITS OF MACKINAC
LAKE HURON
LAKE MICHIGAN
STRAITS OF MACKINAC
MICHIGAN
UPPER PENINSULA
MICHIGAN
LOWER PENINSULA
BCIS BLANC ISLAND
ROUND IS.
MACKINAC ISLAND
ST. IGNACE
MACKINAW CITY
MACKINAC BRIDGE
CHEBOYGAN
ST. HELENA IS.
N
SHIPPING ROUTES

FIGURE 7

upper and lower peninsulas of Michigan is about 4-1/2 miles across. The normal flow is from Lake Michigan to Huron, but the area is broad and deep, and both lakes have the same water surface elevation. The area is generally covered with shifting ice throughout much of the winter.

Prior to the completion of the Mackinac Bridge in 1959, auto-passenger ferries would operate on regular schedules year-round across the Straits. The CHIEF WAWATAM, a large railroad car ferry, continues to operate year-round between Mackinac City and St. Ignace.

Lake Huron: Lake Huron, (Figure 8), has a north-south orientation similar to Lake Michigan, but is considerably wider (maximum width 183 miles) and has a cooler, more uniform temperature differential over its 206-mile length. Traditionally, navigation ceases on this lake during the ice season from mid-December to late March.

Lake Huron has large areas that are protected from deep lake currents with Georgian Bay tending to react to ice formation as an individual lake. Lake Huron proper has three areas that form and accumulate extensive ice-covers early in the season: the Straits in the north; Saginaw Bay; and the southern basin in the Port Huron area.

During a normal ice season, 60 percent of the lake becomes ice-covered. In a severe winter, the lake may become 80 percent ice-covered. In 1979, the lake became 100 percent ice-covered for the first time on record. The southern basin, because of the surface current pattern, collects large amounts of drifting ice that can become concentrated at the entrance to the St. Clair River near Port Huron.


N
ONTARIO
MICHIGAN
DETOUR
DRUMMOND ISLAND
PORT
DOLOMITE
LITTLE CURRENT
STRAITS OF MACKINAC
LAKE
CALCITE
STONEPORT
ALPENA
GEORGIAN BAY
DEPOT
HARBOR
LAKE MICHIGAN
HURON
SAGINAW BAY
CANADA
UNITED STATES
GODERICH
BAY CITY
SAGINAW
MICHIGAN
PORT HURON
SARNIA
LAKE
ST. CLAIR
LAKE HURON

FIGURE 8

The remainder of the lake usually contains areas of drifting floes, brash, and cake ice, with the deep central area remaining almost ice-free. The lake clears rapidly of ice in the spring and, usually, by 5 April, only the north channel, the Straits of Mackinac, and Saginaw Bay contain any ice-cover.

The shallow water of Saginaw Bay loses heat rapidly and is usually the first area to form ice in winter and last to open in the spring. Popular winter activities include ice fishing and snowmobiling on predominantly flat, stable ice cover. A navigation channel is dredged throughout the length of the bay to harbors in Saginaw and Bay City.

Lake Huron Harbors: There are six major harbors in Lake Huron as shown in Figure 8, underlined, and described below.

Drummond Island Harbor, Michigan, is located in DeTour Passage, the outlet of the St. Marys River, in northern Lake Huron. The harbor is primarily used during the open water season to ship limestone, sand, gravel, and crushed rock from the Drummond Dolomite, Inc. quarry.

The ice in DeTour Passage and the harbor area is generally stable fast ice ranging in thickness from two to three feet. South of DeTour Passage, the water is usually ice free but can become ice covered from drift ice pushed north by southerly winds. Within DeTour Passage, a car ferry operates year-round between DeTour Village and Drummond Island within a narrow track kept open by the frequent ferry crossings, and open water of Lake Huron.

Port Dolomite Harbor, Michigan, is a private dock owned by the Michigan Limestone Division of the U. S. Steel Corporation. It is located on the north shore of Lake Huron about three miles east of Cedarville, Michigan. The harbor is not used in winter because limestone processing requires a wet-wash operation that is not

utilized in cold weather. The harbor area is protected by the Les Cheneaux Islands and consequently forms a solid stable ice cover up to three feet thick that remains in place throughout the winter.

Calcite Harbor, Michigan, is located on the westerly shore of Lake Huron about 1-1/2 miles east of Rogers City. The harbor is primarily used during the ice-free months, April through mid-December, to ship out limestone. This commodity cannot be shipped in winter because of the high moisture content resulting from wet-wash processing.

A stable ice cover up to two feet thick generally forms within the harbor. Outside of the harbor entrance the ice occasionally windrows up to five feet thick, but this condition only occurs about four percent of the time. Normally, the outer harbor area is kept open by predominant offshore winds.

Stoneport Harbor, Michigan, located 16 miles north of Alpena Harbor, is privately owned and operated by the Presque Isle Corporation for the shipment of limestone. It is normally closed during the winter months. Ice conditions in and around the harbor may vary from level ice up to 18 inches thick to windrowed ice up to five feet thick. The windrowed conditions are usually transient, lasting one to two days until predominant northwesterly winds blow the ice from the harbor area.

Alpena Harbor, Michigan, is located on the northwest shore of Thunder Bay in northern Lake Huron. The harbor comprises the lowest reach of Thunder Bay River and a reach in the Bay containing major industrial docks. The harbor is generally closed during the coldest part of the winter, January through March. Major commodities shipped are cement, coal, limestone, and fuel oil.

Ice conditions vary from year to year. Heaviest conditions occur when southeasterly winds pack the harbor with ice floes up to three feet in thickness. Northwesterly winds tend to blow the harbor ice into Lake Huron. The river ice is usually stable with an estimated thickness of one foot in a severe winter. During most winters, the bay is open except for periods of jammed or windrowed lake ice which may last from a few days to several weeks.

Ports on the Saginaw River, Michigan, are located along 17 miles of the river at the Cities of Essexville, Bay City, Zilwaukee, Carrollton, and Saginaw. The river is closed to navigation during the winter months. Major commodities shipped during the regular season include limestone, sand, gravel, crushed rock, and cement.

Ice conditions in the river are minor, but a level ice cover up to one foot thick may develop during a severe winter. However, there are numerous weak spots and openings due to thermal discharges from local industrial and municipal facilities. The worst ice conditions exist outside of the river in Saginaw Bay where ice can grow to two foot thick levels and windrow up to six feet thick. The bay is also used for recreation, primarily ice fishing and snowmobiling.

The St. Clair River-Lake St. Clair-Detroit River System connects Lake Huron and Lake Erie (Figure 9). The system is approximately 89 miles long and has a relatively uniform water surface profile with a fall of eight feet from Lake Huron to Lake Erie. The St. Clair River has a length of about 39 miles. Lake St. Clair, extending between the mouth of the St. Clair River and the head of the Detroit River (a distance of about 18 miles) occupies a shallow basin having an average depth of about ten feet, with low, marshy shores in undeveloped areas. The shallow depth requires a dredged commercial navigation channel 27.5 feet deep and 800 feet wide throughout its length. The Detroit River extends about 32 miles to Lake Erie.

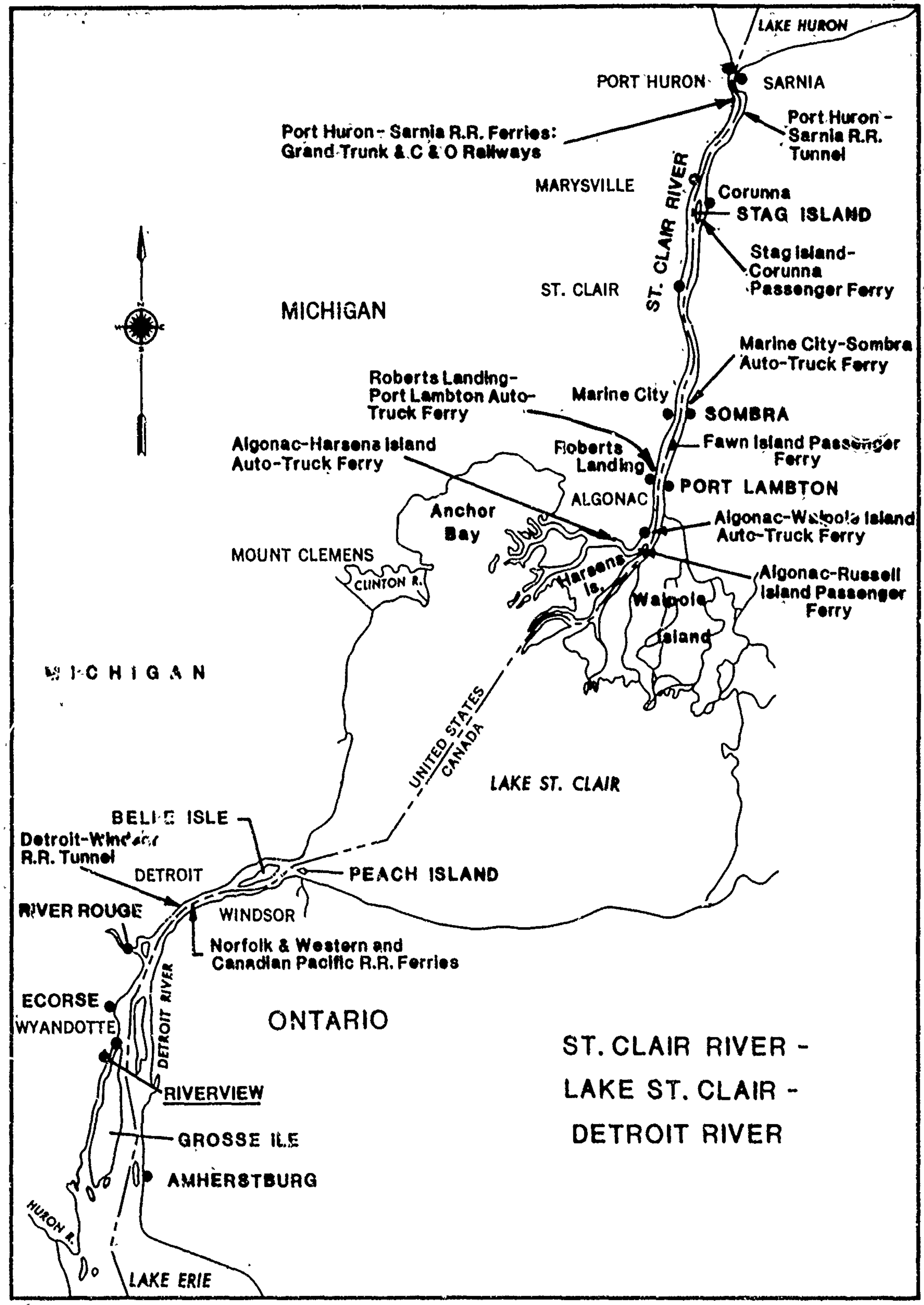

LAKE HURON
PORT HURON
SARNIA
Port Huron - Sarnia R.R. Ferries: Grand Trunk & C & O Railways
Port Huron - Sarnia R.R. Tunnel
MARYSVILLE
ST. CLAIR RIVER
Corunna
STAG ISLAND
Stag Island-Corunna Passenger Ferry
ST. CLAIR
MICHIGAN
Marine City-Sombra Auto-Truck Ferry
Roberts Landing-Port Lambton Auto-Truck Ferry
Marine City
SOMBRA
Algonac-Harsens Island Auto-Truck Ferry
Roberts Landing
Fawn Island Passenger Ferry
PORT LAMBTON
Anchor Bay
ALGONAC
Auto-Truck Ferry
MOUNT CLEMENS
CLINTON R.
Harsens Is.
Algonac-Russell Island Passenger Ferry
Walpole Island
UNITED STATES
CANADA
LAKE ST. CLAIR
PEACH ISLAND
DETROIT
R.R. Tunnel
WINDSOR
Norfolk & Western and Canadian Pacific R.R. Ferries
ECORSE
WYANDOTTE
DETROIT RIVER
ONTARIO
RIVERVIEW
AMHERSTBURG
HURON R.
LAKE ERIE
ST. CLAIR RIVER - LAKE ST. CLAIR - DETROIT RIVER

FIGURE 9

Historically, the St. Clair River does not generally freeze over because of the swift current throughout its length and several thermal discharges from adjacent plants. However, the lower end is frequently covered with broken ice drifting down from Lake Huron and from shore ice generated within its boundaries. An ice cover (bridge) generally forms across the head of the river which stops the inflow of additional ice. However, this ice bridge is occasionally broken by strong winds or midwinter and spring thaws which allow additional ice to flow downstream and jam in the lower river.

Ice jams in the lower river vary in magnitude from year to year. During a mild winter, the ice cover may only back unstream from Lake St. Clair one or two miles. A severe winter has caused ice to jam nearly the entire 39-mile length of the river.

The presence of an ice cover causes a retardation in flow through the system. If strong winds and current cause the ice cover to layer and compact in thickness, a serious ice jam may develop which has caused upstream flooding in the Marine City-Algonac area. The jam also hampers the limited navigation through the area in addition to several ferry operations which continue year-round across the river.

Lake St. Clair lies between the St. Clair and Detroit Rivers. The shallow depth and small surface area of the Lake cause it to react quickly to wind conditions and all temperature changes. The prevailing winds, currents, and inflow from the various channels of the St. Clair River affect the ice-cover. Ice-cover accumulates much faster in the eastern half of the lake. The lake usually becomes ice-covered during the last part of January.

During the period of greatest ice-cover, the distribution varies from thick fast ice in the bays and protected areas to heavy, consolidated floes of brash and cake in the midlake shipping channel. The head of the Detroit River is usually ice-free the entire season except for minor jamming when drift ice becomes concentrated in the area.

The breakup period of the Lake St. Clair ice-cover is short. As breakup progresses, winds and currents move the drifting ice to the entrance of the Detroit River, where strong river currents move it downstream. The western side is the first area to be cleared of ice. The lake is usually ice-free in early March.

An ice bridge usually forms across the head of the Detroit River upstream of Peach Island. The edge of the ice bridge tends to erode upstream during strong wind or thaw conditions, allowing loose ice to enter the river. The quantities of floe ice vary from year to year depending on weather conditions.

The upper half of the Detroit River does not normally freeze over because of its narrow channel and swift current. One exception is the broad, shallow area between Belle Isle and the U.S. mainland. The lower half of the river tends to collect floe ice and freeze over, particularly in the broad shallow areas among the lower islands. The Livingstone Channel, the main shipping lane through the lower river for Detroit-Toledo coal deliveries, tends to remain open except when easterly winds blow Lake Erie ice into the lower river. The westerly end of Lake Erie contains ice fields that periodically shift under prevailing winds. Westerly winds will create large areas of open water downstream of Livingstone Channel and absorb any ice floating through the system.

The total river is occasionally filled with ice for short periods of time during the spring breakup or unusual mid-winter thaws on Lake St. Clair.

Nine ferry lines operate in the St. Clair River during the year with only six attempting to operate year-round. A list of the ferry lines and the normal sailing schedule is shown in Table 3. Locations are shown in Figure 9.

TABLE 3

ST. CLAIR RIVER FERRY LINES

Ferry Company	Cargo	Ports	Sailing Season	Average Days of Discontinued Service [a]
a. Grand Trunk[b] Western Railroad Co.	railroad cars	Port Huron MI Sarnia, Ont	year-round	0
b. C & O Railroad	railroad cars	Port Huron MI Sarnia, Ont	year-round	0
c. (Stag Island)	Passengers	Stag Is. Corunna	April through October	N/A
d. Blue Water Ferry Company	Autos, Trucks & Passengers	Marine City, MI Sombra, Ont	year-round	6
e. (Fawn Island)	Passengers	Fawn Is, Ont Sombra, Ont	April through November	N/A
f. Port Lambton Ferry Service	Autos, Trucks & Passengers	Roberts Landing, MI Port Lambton Ont.	year-round	20
g. Walpole Ferry Line	Autos, Trucks & Passengers	Algonac MI Walpole Is, Ont	year-round	42
h. Russell Island Ferry Company	Passengers	Algonac MI Russel Is, MI	April through October	N/A
i. Champion Auto Ferry, Inc.	Autos, Trucks & Passengers	Algonac, MI Harsens Is, MI	year-round	2

[a] Due to Winter weather, i.e. ice or ice floes, etc.

[b] Connects into the Canadian National Railroad (CN) on the Ontario, Canada side of the river.

The two railroad ferries (GT-CN & C&O), located near the upstream end of the river, are least affected by ice conditions during the winter, since ice jams rarely occur in that area.

The ferries downstream of Marine City are most likely to experience problems due to ice jams each winter, particularly the Wapole Ferry Line at Algonac, Michigan, which stops operating for days or weeks at a time when natural ice conditions keep the small, low powered vessel from operating. The upstream ferries generally operate more frequently and can carry the extra traffic when necessary.

Two railroad car ferries operate year-round across the Detroit River between Detroit and Windsor, Ontario. In addition, there are unscheduled tug-barge crossings carrying oil and salt to various docks up and down the river.

Ferry service disruptions along the St. Clair-Detroit Rivers are all similar and can be described as a single phenomenon. Briefly, the ferry service is interrupted when the ferry landing and approach slips become filled with ice, preventing docking of the ferry. Occasionally, heavy ice jams will prevent the ferry from operating across its normal track.

Winter navigation has continued for many years with almost daily round-trip tug-barge oil deliveries between Sarnia, Ontario, refineries and power plants along the St. Clair and Detroit Rivers. These vessel movements are occasionally aided by Coast Guard icebreakers but are temporarily halted during severe ice conditions. There are also year-round coal deliveries between Toledo, Ohio, and power plants along the Detroit River. Icebreaker assistance is frequently required for coal carriers in western Lake Erie, especially during easterly winds and in heavy ice-severe winter conditions.

While much of the shoreline along the St. Clair-Detroit River system is protected by stone, steel, or wood seawalls, some unprotected shoreline is subject to erosion caused by waves, changing water levels, and moving ice.

Some shore structure damage has also historically occurred, primarily in the lower St. Clair River. Damage was usually caused by current or wind driven ice impacting against the structures. Other damage occurred when a structure was frozen in heavy ice and the ice moved either vertically from changing water levels or laterally due to a shift in the ice pack.

Ports on the St. Clair River, Michigan, shown in Figure 9, are primarily located in the upper river at Port Huron, Marysville, and St. Clair, Michigan. Major commodities shipped into St. Clair and Marysville are coal and fuel oil for the electric generating plants at those ports. Port Huron receives stone, oil, and general cargo. The upper river is usually ice free throughout the winter. However, occasional heavy ice floes drift down from Lake Huron and jam in the lower river. These jams historically cause problems to navigation and can cause flooding upstream of the jam in the Algonac-Marine City area.

Detroit River Harbors, Michigan, shown in Figure 9, are located at Detroit, the Rouge River, Ecorse, Wyandotte, and Riverview.

Generally, the upper river, above Wyandotte, is ice free because of the swift current in the main channel. The lower river is subject to ice jams resulting from ice floes drifting down from Lake St. Clair.

Lake Erie (Figure 10) is the shallowest of all the Great Lakes and has an average depth of 62 feet. It is considerably smaller than

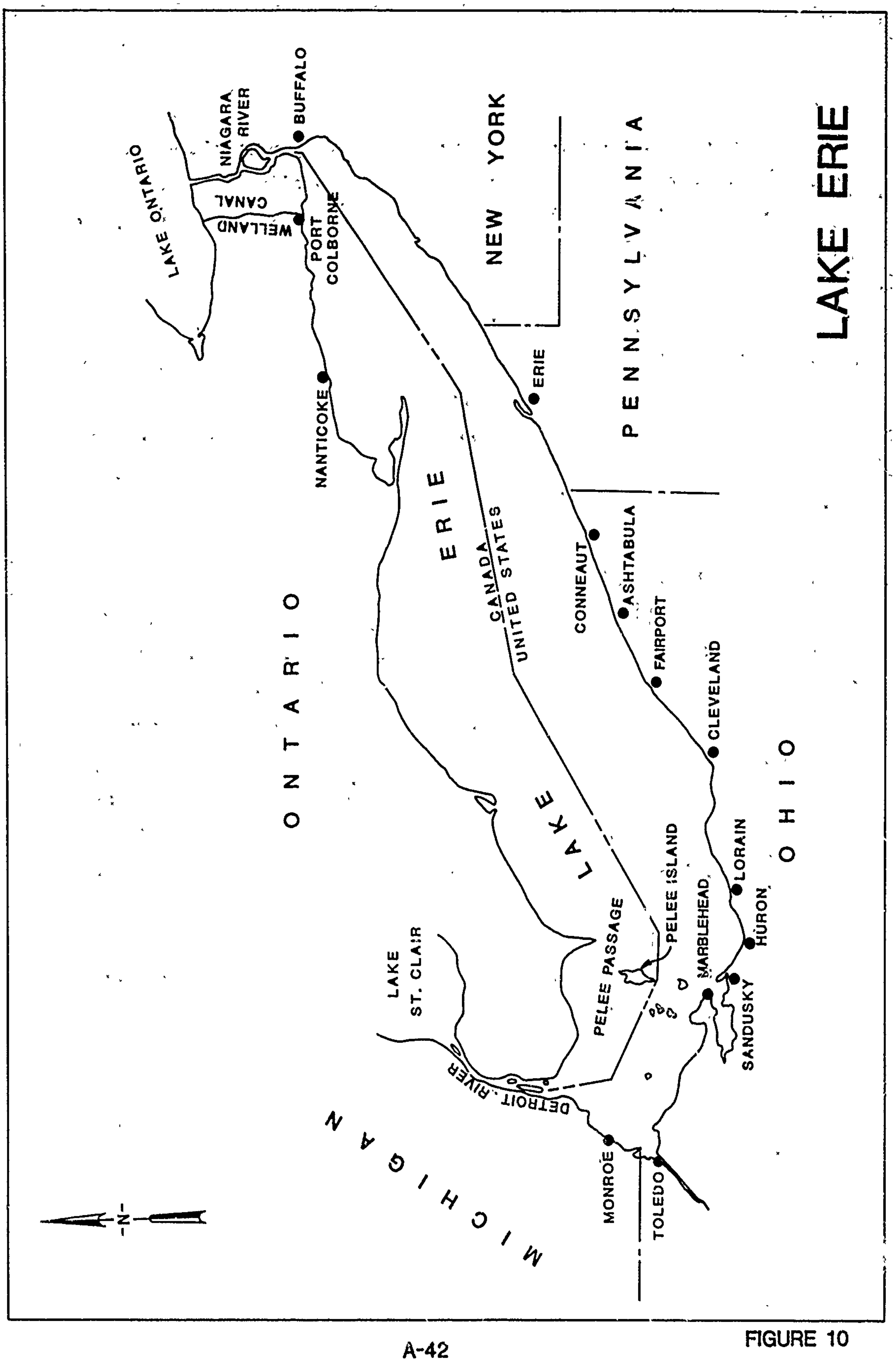

LAKE ERIE
LAKE ONTARIO
NIAGARA RIVER
BUFFALO
WELLAND CANAL
PORT COLBORNE
NEW YORK
PENNSYLVANIA
ERIE
NANTICOKE
ONTARIO
LAKE ERIE
CANADA
UNITED STATES
CONNEAUT
ASHTABULA
FAIRPORT
CLEVELAND
OHIO
LORAIN
HURON
PELEE ISLAND
PELEE PASSAGE
MARBLEHEAD
SANDUSKY
LAKE ST. CLAIR
DETROIT RIVER
MICHIGAN
MONROE
TOLEDO
-N-

FIGURE 10

Lakes Superior, Michigan, and Huron, with a length of 240 miles and a maximum width of 57 miles.

Lake Erie reacts rapidly to seasonal temperature changes and, due to its shallow depth, is the most thermally unstable of the Great Lakes. Because of the rapid response to air temperatures, the lake can accumulate an ice-cover in a short period. Lake Erie normally develops the most extensive ice-cover of any of the Great Lakes, with first ice forming in the shallow, western basin. The ice-cover begins to accumulate in early January and is usually at its maximum by the last week of February. Under the influence of currents and winds, the ice-cover shifts, causing rafting and pressure ridges to form. During a winter season with normal temperatures, it is possible for the Lake to become 95 to 100 percent ice-covered.

The ice-cover is made up of various ice types and concentrations. The western basin contains heavy, winter ice, while the area of the lake located between Sandusky, Ohio, and Erie, Pennsylvania, generally contains vast floes and fields of pack ice of differing concentrations. The eastern basin usually has extensive areas of consolidated floes that are concentrated by the prevailing winds and currents.

Western and central portions of the lake becomes ice-free shortly after breakup, which occurs near the end of February or the beginning of March. The broken, drifting ice is concentrated by winds and currents in the eastern end of the Lake and often remains in the Buffalo area until late April and occasionally until late May.

At the beginning of each winter, since 1965, a floating boom has been placed at the head of the Niagara River at the eastern end of Lake Erie. The purpose of the boom is to aid the formation of a stable ice-cover in the eastern end of Lake Erie and reduce movement of ice into the Niagara River. The desired effects of the boom are

distinctly advantageous towards achieving optimum hydro-electric power generation on the Niagara River and reducing property damages along the River due to massive ice runs from Lake Erie. However, because the boom is located in the Buffalo Harbor area, vessel movement may be impeded by the large accumulation of ice behind the boom.

Some navigation occurs year-round in western Lake Erie with the periodic coal shipments from Toledo, Ohio to power plants along the Detroit River.

Lake Erie contains many of the home ports for United States vessels where vessels lay up for the winter and undergo general maintenance and repair. The major layup ports are: Buffalo, NY, Erie, PA, Conneaut, Ashtabula, Cleveland, and Toledo, OH.

Lake Erie Harbors: There are 12 major harbors in Lake Erie as shown in Figure 10, underlined, and described below.

Monroe Harbor, Michigan, located in the mouth of the River Raisin about 15 miles north of Toledo, Ohio, is normally closed to shipping January through March. The principal cargo shipped in during the regular season is coal for the Detroit Edison generating plant. A steel plant is now being constructed in the area. The ice cover in the navigation channel consists of solid shorefast ice that may reach 12 inches in thickness; but it may reach two feet in thickness at the harbor entrance. On rare occasions, windrows will form outside the harbor entrance when strong easterly winds blow the ice field against the shoreline.

Toledo Harbor, Ohio, is located in the mouth of the Maumee River at the western end of Lake Erie. Major commodities shipped through the harbor are coal, iron ore, corn, and soybeans. Coal is normally shipped year-round to power plants along the Detroit River. Ice conditions in the harbor range from nine inches of level ice in the

navigation channel to level ice up to two feet thick in the harbor entrance.

Marblehead Harbor, Ohio, is comprised of a private dock extending directly into deep, unsheltered lake water, and a shallow, (eight ft.) sheltered basin that is part of the Marblehead Coast Guard station. The dock is used primarily to ship out limestone, sand, and gravel during the ice-free months. Ice conditions at the dock range from a maximum of two feet of level ice to, on rare occasions, wind driven ice piles up to ten feet thick. The windrowed condition is usually temporary, lasting less than five days before predominant offshore winds blow the ice back into the lake.

Sandusky Harbor, Ohio, is located in shallow Sandusky Bay, about 55 miles west of Cleveland, Ohio. A dredged channel extends from deep water across the bay to the docks and turning basin. Coal, limestone, and gypsum are the principal commodities shipped out of the harbor during the ice-free months. Ice conditions in Sandusky Bay and Harbor are generally stable with ice thickness ranging between open water conditions and 20 inches, depending on the severity of the winter. Normally, ice cover is between eight and ten inches thick.

Huron Harbor, Ohio, is located at the mouth of the Huron River, about 47 miles west of Cleveland, Ohio. The normal shipping season is from early April to late December. Major commodities shipped at this harbor are iron ore, limestone, and soybeans. The inner harbor usually forms a stable ice cover that may reach 20 inches in thickness. In addition, occasional ice jams and windrows may form across the entrance channel. This condition is usually temporary, rarely lasting more than five days before offshore winds blow the jammed ice back into the lake.

Lorain Harbor, Ohio, is located at the mouth of the Black River, about 28 miles west of Cleveland, Ohio. The port consists of an outer harbor protected by a series of converging breakwaters and an inner harbor including the lower three miles of the Black River. Major commodities shipped into the harbor by U.S. Steel are iron ore, coal, and limestone. Ice conditions in the river and harbor can reach a maximum thickness of two feet. Ice conditions at the harbor entrance vary with the wind conditions. Southwesterly winds will cause drifting lake ice to jam and windrow, at times reaching to the channel bottom. This condition rarely exists more than a few days, but on rare occasions may last up to a month.

Cleveland Harbor, Ohio, consists of an outer harbor that extends along the lake front for five miles, and an inner harbor consisting of 5.8 miles of the Cuyahoga River and one mile of the Old River. The harbor is normally closed to navigation January through March. Major commodities shipped at the harbor are taconite iron ore, limestone, and non-metallic minerals.

The Cuyahoga River rarely freezes over due to the heated effluent from the steel mills upriver. Ice thickness in the outer harbor is usually less than 18 inches but may reach 24 inches in a severe winter. Ice conditions at the harbor entrance are dependent on wind conditions. Ice jams up to 16 feet thick have been reported. These conditions rarely last more than four days at a time before winds shift and blow the ice away from the harbor.

Fairport Harbor, Ohio, is located about 33 miles northeast of Cleveland and consists of an outer harbor and inner harbor at the mouth of the Grand River. Major commodities shipped during the ice-free months are limestone, sand, gravel, crushed rock, and non-metallic minerals. Ice conditions at the harbor entrance may include ice up to two feet thick and windrows up to 15 feet thick. The windrowed condition is transient. The magnitude, frequency, and duration is directly related to wind conditions. Ice conditions in

the navigation channel and dock area usually consist of level ice, ranging in thickness between one and two feet.

Ashtabula Harbor, Ohio, located about 59 miles northeast of Cleveland, Ohio, consists of a protected outer harbor and an inner harbor extending about two miles up the Ashtabula River. The harbor is normally closed three to four months each winter. The major commodities shipped are iron ore, coal, and limestone. Ice conditions in the inner harbor and river usually consist of loose ice floes up to 12 inches thick. Ice in the outer harbor rarely exceeds two feet in thickness. Ice jams extending to the channel bottom can temporarily form at the harbor entrance during periods of strong onshore winds. This condition is transient, and southerly winds will eventually move the ice jams into the lake.

Conneaut Harbor, Ohio, located about 73 miles northeast of Cleveland, Ohio, has an inner and outer harbor similar to Ashtabula Harbor. The inner harbor consists of two piers, about 2,400 feet long along both sides of Conneaut Creek. Major cargo shipped during the ice-free months are iron ore, coal, and limestone. Ice conditions in the inner harbor and river consists of floating ice floes or brash ice up to 16 inches thick. The harbor is most severely affected by infrequent northerly winds occurring about two percent of the time, which blow drift ice into the harbor area. Ice can jam to the channel bottom. In addition, waves up to 20 feet high tend to aggravate the problem.

Erie Harbor, Pennsylvania, is located about 90 miles northeast of Cleveland, Ohio, in Presque Isle Bay, a body of water enclosed by Presque Isle Peninsula. Major cargo shipped during the ice free months are sand, gravel, limestone, and non-metallic materials.

Erie harbor is highly sheltered and develops a solid ice cover that may reach up to three feet in thickness under extreme conditions.

Ice in the navigation channel and turning basin may reach two feet in thickness. On rare occasions, ice jams occur outside of the harbor entrance due to strong northeasterly winds. Such conditions usually last less than two days with a maximum duration of five days.

Buffalo Harbor, New York, consists of about 4.5 miles of lakeshore protected by breakwaters, plus sections of the Buffalo River, the Niagara River, and several short ship canals. Major cargo shipped during the ice-free months are iron ore, limestone, and wheat.

During a severe winter, ice conditions within the harbor may reach a maximum thickness of about two feet. Outside the harbor, the prevailing southwest winds normally raft and pile the ice to thicknesses of several feet. During spring breakup, the south entrance to Buffalo Harbor usually is passable before the north entrance. However, this can change from day to day depending on the direction of the wind and consequent ice movement.

The Black Rock Canal and the channel to Tonawanda will freeze over during a severe winter with a level ice thickness of about one foot. The Tonawanda Channel very rarely freezes over because the velocity is too high. During the spring breakup, the eastern end of Lake Erie is usually filled with heavily layered ice blown in by the prevailing winds. This condition often lasts until May and contains the last ice to leave the area.

The Niagara River, shown in Figure 11, about 36 miles in length, is the natural link between Lake Erie at Buffalo, New York, and Lake Ontario at Niagara-on-the-Lake, Ontario. The average fall over its course is 326 feet, about half of which occurs at Niagara Falls.

Welland Canal: Vessel traffic between Lake Erie and Lake Ontario uses the Welland Canal, which lies in Canada. The Welland Canal,

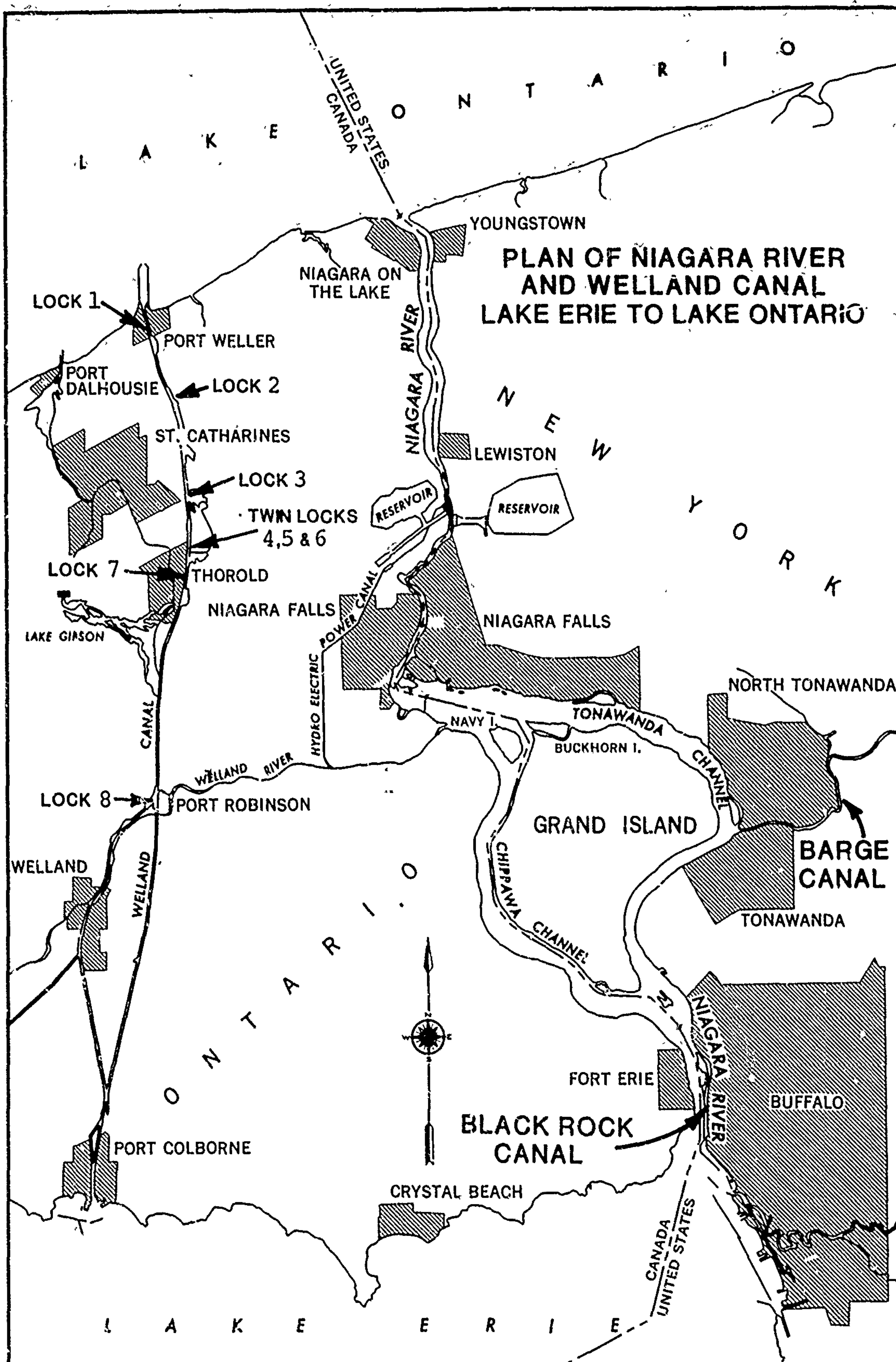

PLAN OF NIAGARA RIVER
AND WELLAND CANAL
LAKE ERIE TO LAKE ONTARIO
LAKE ONTARIO
UNITED STATES
CANADA
YOUNGSTOWN
NIAGARA ON THE LAKE
LOCK 1
PORT WELLER
PORT DALHOUSIE
LOCK 2
ST. CATHARINES
LOCK 3
TWIN LOCKS 4,5 & 6
LOCK 7
THOROLD
NIAGARA FALLS
LAKE GIBSON
NIAGARA RIVER
NEW YORK
LEWISTON
RESERVOIR
RESERVOIR
HYDRO ELECTRIC POWER CANAL
NIAGARA FALLS
NORTH TONAWANDA
TONAWANDA CHANNEL
NAVY I.
BUCKHORN I.
GRAND ISLAND
BARGE CANAL
TONAWANDA
CANAL
WELLAND RIVER
LOCK 8
PORT ROBINSON
WELLAND
WELLAND
ONTARIO
CHIPPAWA CHANNEL
NIAGARA RIVER
FORT ERIE
BUFFALO
BLACK ROCK CANAL
PORT COLBORNE
CRYSTAL BEACH
CANADA
UNITED STATES
LAKE ERIE

FIGURE 11

(Figure 11), with a minimum depth of 27 feet, connects Lake Erie at Port Colborne, Ontario, with Lake Ontario at Port Weller, Ontario, and is completely owned and operated by the Canadian Government (St. Lawrence Seaway Authority). The canal is approximately 27 miles long and overcomes a difference in level of about 326 feet by a series of seven lift locks and one guard lock. Ships not exceeding 730 feet in overall length and 75.5 feet in width may transit the canal.

The Welland Canal normally closes for the winter when demand ceases, generally from mid-December to early April. It does not have a fixed operating season, but generally utilizes the winter months for maintenance and repair of lock facilities.

Black Rock Canal: The Black Rock Canal parallels the upper reach of the Niagara River from Buffalo Harbor to the downstream portion of Squaw Island. The canal, normally closed during the winter, has a depth of 21 feet and provides an alternate route around the constricted and shallow reach at the head of Niagara River. The Black Rock Lock, which has a lift of five feet, is located near the lower end of the canal. The navigation channel rejoins the river below Squaw Island where the river widens. From Tonawanda to Niagara Falls, New York, a navigation channel with minimum depth of 12 feet below low water datum (LWD) is maintained.

New York State Barge Canal: The New York State Barge Canal has a depth of 12 feet and is closed during the winter months. It extends eastward from Tonawanda, New York, linking the Niagara River with the Hudson River near Albany, New York. Near Syracuse, New York, an extension runs northward into Lake Ontario at Oswego, New York.

Lake Ontario (Figure 12), the Great Lake immediately upstream of the St. Lawrence River, is also the smallest with a length of 193 miles and a maximum width of 53 miles.

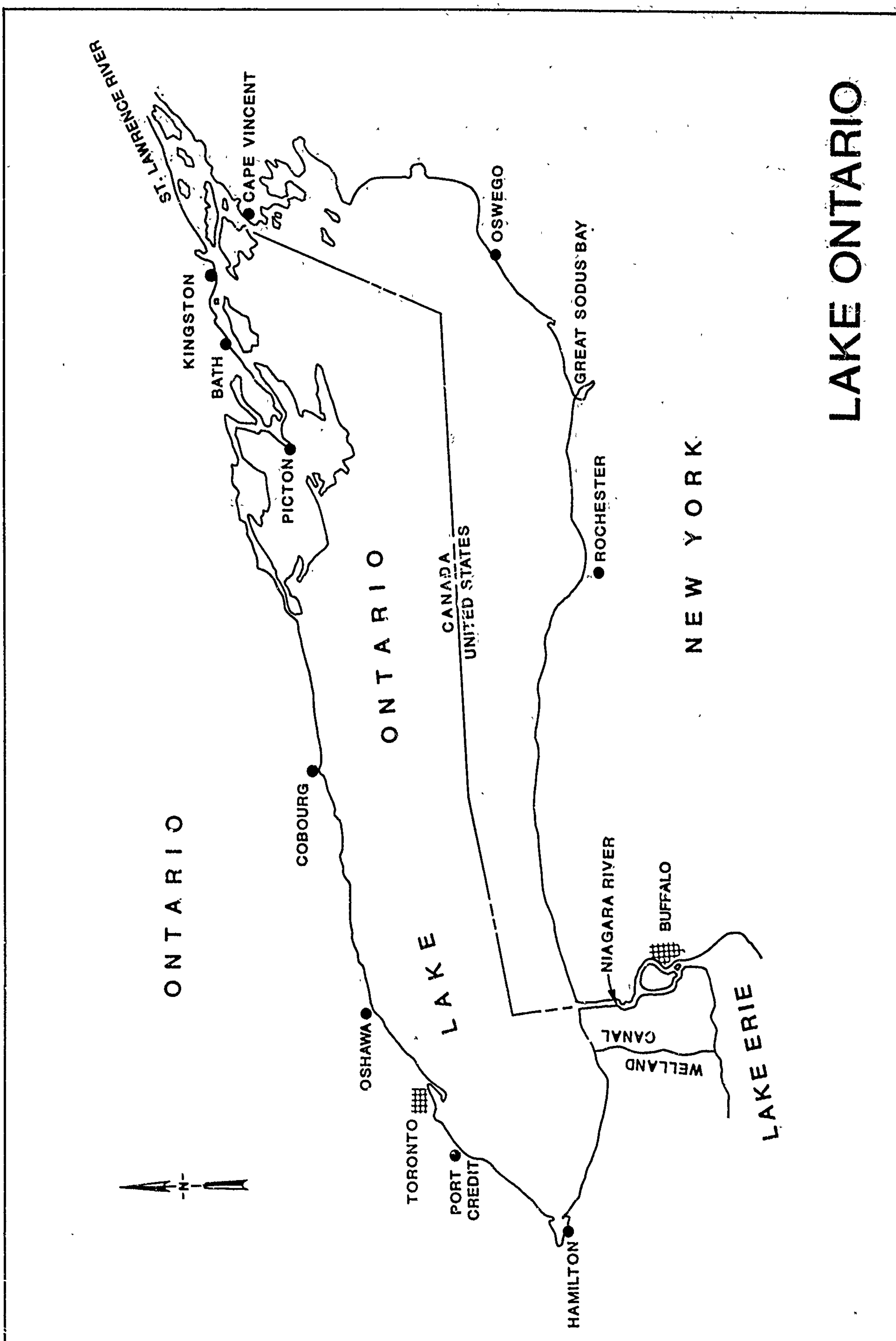

LAKE ONTARIO
ST. LAWRENCE RIVER
CAPE VINCENT
KINGSTON
BATH
PICTON
OSWEGO
GREAT SODUS BAY
ROCHESTER
NEW YORK
ONTARIO
CANADA
UNITED STATES
ONTARIO
COBOURG
LAKE
OSHAWA
TORONTO
PORT CREDIT
HAMILTON
NIAGARA RIVER
BUFFALO
WELLAND CANAL
LAKE ERIE
N

FIGURE 12

Lake Ontario has the smallest surface area of all the Great Lakes, but has a mean depth that is second only to Lake Superior. The combination of small surface area and great depth gives this lake a large heat-storage capacity, causing it to respond slowly to changing air temperatures. This response to climatic change affects the amount of ice-cover produced, which is the smallest amount of any of the Great Lakes.

An extensive ice-cover formation does not appear until late January and is confined to the east end of the Lake. Under normal conditions, the greatest extent of ice-cover occurs near the middle of March and occupies 15 percent of the Lake surface. Ice covers about 25 percent of the Lake surface during a severe winter. However, in February 1979, the ice cover exceeded 95 percent. The ice-cover is generally fast ice and the prevailing winds and currents tend to confine and concentrate the ice-cover at the northeastern end of the Lake and the approaches to the St. Lawrence River. The Lake is generally ice-free early in April except for isolated drift ice and ice in some protected bays.

Two commercial harbors exist on the United States side at Rochester and Oswego, New York (see Figure 12). They are relatively small harbors and are not normally used for the winter lay up of vessels.

Rochester Harbor, New York, is located at approximately the middle of the southern shore of Lake Ontario at the mouth of the Genesee River. The harbor is normally closed to navigation in winter. However, prior to 1950, the harbor was kept open year-round to accommodate car ferry traffic to Cobourg, Ontario. At present, cement is the only cargo shipped into Rochester Harbor. Because of the location of the harbor, prevailing winds and current tend to keep drift ice away from the harbor entrance. The river, harbor, and dock area remains ice free most of the winter. Maximum ice cover during severe winters is generally two to three inches, which should not hamper winter navigation.

Oswego Harbor, New York, is located about 45 miles south of the head of the St. Lawrence River. The harbor is the terminus of the Oswego Canal, of the New York State Barge Canal System, and consists of an outer harbor enclosed by a breakwater and an inner terminal harbor in the Oswego River. The normal navigation season corresponds to the opening and closing of the Welland Canal and the Seaway. Major commodities shipped at the harbor are fuel oil, cement, and crude petroleum.

Occasionally, a serious ice jam problem will develop at the harbor entrance when southwesterly winds cause ice to layer into thick windrows. This condition is transient, but may last from a few days to a few weeks until offshore winds shift the ice back into the lake. Ice conditions in the harbor and dock areas are minimal due to the river current and power plant thermal discharge.

<u>The St. Lawrence River System</u> (Figure 13), extends from the outlet of Lake Ontario, at Kingston, Ontario, to Father Point, Quebec. The section between Lake Ontario and Montreal is commonly called the Seaway portion of the river and can be divided into three sections. The lower section, from Montreal at the Jacques Cartier bridge to the mouth of the St. Regis River, is 73 miles long. It is entirely in Canadian territory and under the jurisdiction of the St. Lawrence Seaway Authority of Canada. The middle section, from the mouth of the St. Regis River to Iroquois Lock and Dam, is about 36 miles long. The upper section, from the Iroquois Lock and Dam to Tibbetts Point, is about 80 miles long. The river embraced by the middle and upper sections, referred to as the International Section, separates the United States and Canada, and is under the joint navigational control of the St. Lawrence Seaway Development Corporation, a corporate agency of the United States, and the St. Lawrence Seaway Authority of Canada. Located along the River are

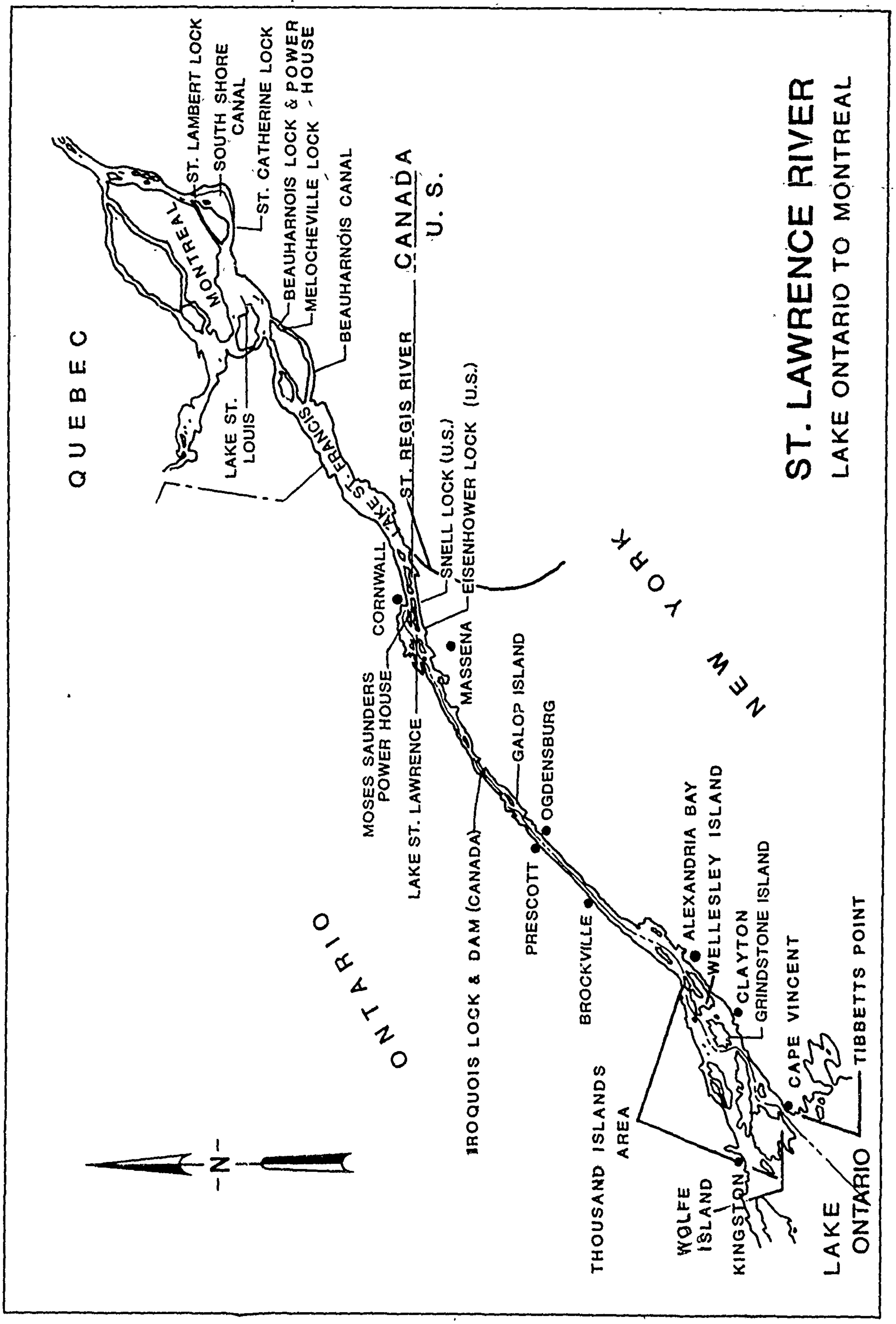

ST. LAWRENCE RIVER
LAKE ONTARIO TO MONTREAL
QUEBEC
ONTARIO
NEW YORK
CANADA
U. S.
N
MONTREAL
ST. LAMBERT LOCK
SOUTH SHORE CANAL
ST. CATHERINE LOCK
BEAUHARNOIS LOCK & POWER HOUSE
MELOCHEVILLE LOCK
BEAUHARNOIS CANAL
LAKE ST. LOUIS
LAKE ST. FRANCIS
ST. REGIS RIVER
SNELL LOCK (U.S.)
EISENHOWER LOCK (U.S.)
CORNWALL
MASSENA
MOSES SAUNDERS POWER HOUSE
LAKE ST. LAWRENCE
GALOP ISLAND
OGDENSBURG
IROQUOIS LOCK & DAM (CANADA)
PRESCOTT
BROCKVILLE
ALEXANDRIA BAY
WELLESLEY ISLAND
CLAYTON
GRINDSTONE ISLAND
CAPE VINCENT
TIBBETTS POINT
THOUSAND ISLANDS AREA
WOLFE ISLAND
KINGSTON
LAKE ONTARIO

FIGURE 13

large power complexes, such as the Moses-Saunders Powerhouses, operated by the Power Authority of the State of New York and Hydro-Electric Power Commission of Ontario, and the Beauharnois Powerhouse, operated by the Quebec Hydro-Electric Power Commission. The maximum permissible vessel draft in Seaway channels from Montreal to Lake Ontario is 25-3/4 feet. The main Seaway channels have a controlling depth of 27 feet. There are seven locks in the system, two of which are operated by the United States and five by Canada. The locks are all 766 feet long and 80 feet wide, which permits transit of vessels up to 730 feet long and 75.5 feet wide.

In the 169 miles of river between Montreal and Quebec City, the fall is about 25 feet at low tide. Below Quebec City, the river gradually widens into the St. Lawrence estuary and finally the Gulf of St. Lawrence. The navigation channel at and below Montreal is referred to as the St. Lawrence Ship Channel with an advertised depth of 35 feet at low water datum. Downstream of Quebec City, the present controlling depth is 30.0 feet Lowest Normal Tide (LNT) and these channels are currently being deepened to 41.0 feet LNT.

The St. Lawrence River flows northeast 530 miles from Lake Ontario to its mouth at Father Point, Quebec. The winter ice-cover usually forms first along the south shore canal between Montreal and Lake St. Louis in early to mid-December and advances upriver to Lake Ontario. Mid-winter conditions usually consist of fast ice which is not generally subjected to breakup from wind or current conditions. Ice thickness in channel sections may average two to three feet while lake and river ice may only reach a thickness of 1.5 to 2.5 feet.

Floating ice booms are installed annually by the power authorities (Power Authority of the State of New York, Ontario-Hydro of Canada, and Quebec-Hydro of Canada) along the river at the beginning of winter. These booms assist in the stabilization of the ice cover on the river to reduce the occurrence of ice jams which

have an adverse effect on power generation (i.e. reduction in flow in the river). Hence, with the consideration of extended season navigation on the river, they are an impediment to navigation. The ability to transit these booms during winter, without disrupting the stable ice cover, is a very important part of this study.

Traditionally, navigation ceased about 15 December and resumed about 1 April. Reduced winter discharge rates and water velocities, coupled with stable shorefast ice conditions, caused only generally acceptable shoreline problems.

Harbors: There are presently 60 U. S. commercial harbors that have received Federal support on the Great Lakes with depths ranging from 16 to 28 feet. In addition, there are 15 private deep-draft harbors in the Great Lakes System. A list of these harbors is shown on Table 4. Harbors in the study area are shown in Figure 1.

The Mid-continent has been deeply involved in international trade for many years, providing impetus for the development and expansion of ports. It is through these ports that ever-increasing tonnages of bulk and general cargoes--grain, iron ore, coal and manufactured goods--pour into the commerce of the hemisphere and the world. Each year ships move exports and imports into and out of this vast region through the St. Lawrence Seaway. Ships traveling the inland route are lifted 600 feet from the sea by seven St. Lawrence Seaway Locks, eight Welland Canal Locks, and the four U.S. Sault Ste. Marie Locks.

STATUS OF EXISTING NAVIGATION PLANS AND IMPROVEMENTS

Navigation System

Improvement of the existing connecting channels above Lake Erie was authorized on 21 March 1956. The improvement provided for increasing controlling depths from 24.8 feet and 21 feet below water

TABLE 4
U.S. GREAT LAKES COMMERCIAL & PRIVATE HARBORS

Commercial

Lake Superior

Grand Marais, Minn.
\+ Two Harbors, Minn.
\+ Duluth-Superior, Minn-Wis.
\+ Ashland, Wisconsin
Ontonagon, Mich.
\+ Presque Isle, Mich.
\+ Marquette, Mich.
Kewenaw Waterway, Mich.

Lake Michigan

Menominee, Mich. & Wis.
\+ Green Bay, Wis.
Sturgeon Bay, Wis.
Kewaunee, Wis.
Two Rivers, Wis.
\+ Manitowoc, Wis.
Cheboygan, Wis.
Port Washington, Wis.
\+ Milwaukee, Wis.
Racine, Wis.
\+ Kenosha, Wis.
Waukegan, Ill.
\+ Chicago, Ill.
\+ Calumet Harbor, Ind. & Ill. & Lake Calumet
\+ Indiana Harbor, Ind.
Burns Waterway, Ind.
Michigan City, Ind.
St. Joseph, Mich.
South Haven, Mich.
Holland, Mich.
Manistique, Mich.
Gladstone, Mich.
Grand Haven, Mich.

Lake Michigan (cont'd)

\+ Muskegon, Mich.
White Lake, Mich.
Ludington, Mich.
Manistee Harbor, Mich.
Frankfort, Mich.
Charlevoix, Mich.

Lake Huron

\+ Alpena, Mich.
Cheboygan, Mich.
\+ Saginaw, Michigan
Harbor Beach, Mich.

St. Clair/Detroit Rivers

Marysville, Mich.
Port of Detroit, Mich. Detroit River
\+ Rouge River
\+ Trenton, Channel
Monroe, Mich.

Lake Erie

\+ Toledo, Ohio
\+ Sandusky, Ohio
\+ Huron, Ohio
\+ Lorain, Ohio
\+ Cleveland, Ohio
\+ Fairport, Ohio
\+ Ashtabula, Ohio
\+ Conneaut, Ohio
\+ Erie, Pa.
\+ Port of Buffalo, N.Y.

Lake Ontario

\+ Rochester, N.Y.
\+ Great Sodus Bay, N.Y.
\+ Oswego, N.Y.
Ogdensburg, N.Y.

Private

Lake Superior

Taconite, Minn.
Silver Bay, Minn.

Lake Michigan

Oak Creek, Wis.
Buffington, Ind.
Gary, Ind.
Port Dolomite, Mich.
Port Inland, Mich.
Escanaba, Mich.
Petoskey Penn Dixie Harbor, Mich.

Lake Huron

Calcite, Mich.
Stoneport, Mich.
Port Gypsum, Mich.
Alabaster, Mich.
Drummond Island, Mich.

Lake Erie

Marblehead, Ohio

Legend
\+ 30 harbors (Great Lakes Harbors Study 1966)

datum in downbound and upbound channels, respectively, to a controlling depth of 27 feet below lower water datum in both downbound and upbound channels. The channels were designed to provide a safe draft of 25.5 feet for Great Lakes freighters when the water level is at low water datum. To provide this safe draft, project depths varied from 27 to 30 feet to provide allowances for squat of a vessel when underway, for exposure to wave action, and for an additional foot of clearance between safe draft and channel depth for hard bottom, where applicable. The project depths have been available through the Connecting Channels since June 1962.

Locks

The existing St. Marys River U.S. project provides for the operation of four U.S. locks in the St. Marys River at Sault Ste. Marie, Michigan. There is also one lock on the Canadian side of the river at Sault Ste. Marie, Ontario. The principal features of the locks are shown in Table 2.

Controlling depths of 27 feet have been available since 1959 in the Welland Canal between Lake Erie and Lake Ontario, and in the St. Lawrence River from Lake Ontario to Montreal, Quebec. There is a 35-foot ship channel in the St. Lawrence River from Montreal to the Atlantic Ocean. The seven St. Lawrence River locks are the same useable size as the Welland Canal locks.

The limiting dimensions for ships in the MacArthur Lock at St. Marys Falls Canal and for the Welland Canal and St. Lawrence River locks are 730 feet in length and 76 feet (75.5 feet - St. Lawrence and Welland Locks) in beam. The limiting dimensions of ships transiting the new Poe Lock at St. Marys Falls Canal are 1,100 feet long and 105 feet in beam. The MacArthur and Poe Locks in the

St. Marys River and the locks in the Welland Canal and St. Lawrence River have depths in excess of channel depths leading to the locks. The depth over sills is 31 feet for the MacArthur Lock, 32 feet for the Poe Lock, and 30 feet for locks in the Welland Canal and St. Lawrence River. The draft of ships is limited by channel depths, and not currently by the locks.

Harbors

Improvements and construction are essentially complete and provide for a 27-foot Great Lakes System at low water datum. The same allowances between depth and draft used in the connecting channels were used in improving the harbors. Additional depth is provided in entrances and outer harbors as required, due to wave action in exposed areas, due to squat of ships underway, and due to the presence of hard bottom. Depths providing for a safe vessel draft of 25.5 feet at low water datum vary from 27 feet to 30 feet. The Corps of Engineers has under study the feasibility of further improvements in the Great Lakes Connecting Channels and Harbors for the safe operation of vessels up to the maximum depth permitted by the locks at Sault Ste. Marie, Michigan. Also, this study includes a review of reports to determine the advisability of providing additional lockage facilities and increased capacity at the locks at Sault Ste. Marie, Michigan. Independent studies are also on-going for selected harbors within the system and for twinning the United States locks in the St. Lawrence Seaway.

MOST PROBABLE FUTURE

This final report is prepared on the assumption that the recommendations in the March 1976 Interim Feasibility Report would be implemented prior to initiation of recommendations in this final report. Therefore commercial navigation on the upper four Great Lakes to 31 January (plus or minus two weeks) is the "base condition" for this report and continuation thereof is considered to be the

"MOST PROBABLE FUTURE," in addition to traditional intra-lake traffic movement.

The March 1976 Interim Report recommendations provide for extended season navigation on the upper four Great Lakes and its Connecting Channels to 31 January, plus or minus two weeks, depending on ice and weather conditions between non-ice restricted harbors. The major non-ice restricted harbors (up to 31 January, plus or minus two weeks) are as follows:

Lake Superior	-	Two Harbors, MN
	-	Taconite, MN
	-	Silver Bay, MN
	-	Presque Isle, MI
	-	Marquette, MI
Lake Michigan	-	Burns Harbor, IN
	-	Gary, IN
	-	Indiana Harbor, IN
	-	Milwaukee, WI
	-	Calumet, IL
	-	Muskegon, IL
	-	Ludington, IL
Lake Huron	-	Saginaw River
Detroit Harbor		
Lake Erie	-	Toledo, OH
	-	Lorain, OH
	-	Cleveland, OH
	-	Ashtubula, OH
	-	Coneaut, OH
	-	Buffalo, NY

With the implementation of extended season navigation to 31 January, plus or minus two weeks, on the upper four Great Lakes savings would be realized - savings from transportation rate differentials between the Great Lakes-St. Lawrence Seaway and alternative transport modes, reduced stockpiling would lead to

savings in capital and handling costs, and savings by more efficient utilization of the existing vessel fleet which lower the annual freight rates for Great Lakes vessels.

In addition, with the implementation of the 31 January, plus or minus two weeks, extended season certain adverse impacts were identified. The impacts identified were those associated with disruption of ferry transportation at Sugar and Lime Islands in the St. Marys River and shoreline disruption in the St. Marys and St. Clair Rivers-Lake St. Clair-Detroit River System. Mitigation measures, as presented in the Chief of Engineers report dated 16 November 1977, were recommended to mitigate against these impacts. Provisions for an ice boom and bubbler-flusher were included for Sugar Island and an airboat for Lime Island. Provisions for shore structure protection and shore erosion protection above the ordinary high water mark was also included for the St. Marys-Lake St. Clair-Detroit Rivers System for damages caused by extended season operations. Also, an environmental appraisal program to be conducted concurrently with implementation of the first three years of operation to further reinforce existing environment assessments and to provide objective information for development of mitigative measures, if required, was included.

After 31 January (plus or minus two weeks) extended season navigation ceases, adverse impacts on shore structures and shoreline, not protected under the 31 January authorized protection, is expected to continue due to natural conditions (i.e. thawing, winds).

In addition to navigation season extension to 31 January (plus or minus two weeks) on the upper four Great Lakes, traditional winter movement is expected to continue, namely, rail and car ferry operation on Lake Michigan and on the St. Marys, St. Clair, and Detroit Rivers, coal movement from Toledo to Detroit, and various petroleum product movements in Lake Michigan and the Detroit area.

It is important to note that existing legislation does not prohibit winter navigation on the Great Lakes. Prior to the development of taconite pellet process in the late 1950's, navigation ceased during the winter months because it was not practical to handle frozen cargoes, especially iron ore. With the advent of the low moisture content of taconite pellets, handling of iron ore in the winter months is feasible.

Many vessels in the existing Great Lakes fleet, such as the recently constructed 1,000 foot bulk carriers, have the structural and power capabilities to operate in ice. This, together with the ease of handling iron ore pellets in the winter months, illustrates the potential of increased iron ore movement during the winter months. It is expected that industry would attempt to operate as long as possible into the winter months in the upper four lakes until operation became too difficult to make it profitable for them or until impacts, such as on island transportation, became too severe. Dates of first and last vessel passages through the Soo Locks from 1960-1979 are shown in Table 5.

Generally, cargo is moved by alternative modes of transportation during the winter months (shipping companies consider stockpiling of general cargo uneconomical because of its relatively high value per ton as compared to bulk cargo). However, bulk commodities are stockpiled during the winter months because of their relatively low value per ton as compared to general cargo (shippers consider it more economical to stockpile bulk commodities, such as iron ore, grain, and stone products, during the winter months than ship the commodities by alternative modes of transportation). This type of operation is expected to continue.

More specifically, there has been intralake traffic on the Lakes; primarily Lake Michigan and western Lake Erie, and also along the St.

TABLE 5
SOO LOCKS - CLOSING DATES
1960 - 1979

Winter	Date of 1st Vessel Passage[a]	Date of Last Vessel Passage
1960-61	7 April	19 December
1961-62	8 April	18 December
1962-63	12 April	19 December
1963-64	10 April	20 December
1964-65	1 April	16 December
1965-66	14 April	18 December
1966-67	1 April	20 December
1967-68	10 April	31 December
1968-69	2 April	4 January (69)
1969-70	2 April	11 January (70)
1970-71	1 April	29 January (71)
1971-72	6 April	1 February (72)
1972-73	7 April	8 February (73)
1973-74	28 March	7 February (74)
1974-75	2 April	Continual Operation
1975-76	Continual Operation	Continual Operation
1976-77	Continual Operation	23 January (77)[b]
1977-78	17 March	Continual Operation
1978-79	Continual Operation	Continual Operation

NOTES: (a) In each year a lock was ready on 1 April to transit a vessel, per 33 CFR 207.440.

(b) A convoy of two tankers proceeded upbound through the locks on 13 February 1977, and passed through the locks downbound on 23 February 1977.

Clair-Lake St. Clair-Detroit River System, during the winter months, principally for transport of petroleum, coal, stone products, and iron ore. This traffic is expected to continue. Table 6 displays a summary of these commodities as collected by telephone surveys and from vessel receiving reports provided by the shipping companies for the period of 1971 to 1975 (data prior to 1971 is not available for cargo movement after 15 December). These data are considered to be indicative of the expected commodity movement in the future.

TABLE 6

INTRALAKE WINTER TRAFFIC (1971-75)

(1,000 Tons)

Commodity	71-72	72-73	73-74*	74-75*
Iron Ore	39.0	951.9	1,024.3	1,376.2
Grain	-	-	119.0	119.8
Coal	1,064.7	563.4	1,534.7	1,724.9
Stone	140.5	464.0	1,096.6	1,078.1
Petroleum Products	366.6	727.4	958.2	812.6
Other	34.4	227.2	798.3	369.7
TOTAL	1,645.2	2,933.9	5,531.1	5,481.3

* - years are based on more comprehensive shipping data and are more reflective of winter traffic than the figures shown for 71-72 and 72-73.

The Great Lakes Connecting Channels between Lakes Superior and Huron, and Lakes Michigan and Huron, namely the St. Marys River and the Straits of Mackinac, respectively, freeze over entirely during the winter months and are difficult to navigate without icebreaking assistance from the U.S. Coast Guard. Ice thicknesses up to several feet in both these areas, tight turns in the St. Marys River, lack of winterized navigation aids, low power capabilities of vessels, and increased risks reflected in increased marine insurance costs have, in the past, discouraged shipping during the winter months in these areas. Measures provided in the 31 January extended season navigation plan enable operation to 31 January (plus or minus two weeks) on the upper four Great Lakes. However, there are no provisions for operation beyond this time.

Vessel movement during the winter months in the St. Clair-Lake St. Clair-Detroit Rivers System has in the past been minimal with the exception of stone movement from Lake Huron into the St. Clair-Detroit Rivers, coal movement to Detroit from Toledo, and oil movement between Sarnia, Ontario and Detroit. This movement is expected to continue. The St. Clair River does not generally freeze over; however, it is occasionally laden with broken ice floating into it from Lake Huron in addition to ice generated within its boundaries. This broken ice has a tendency to jam in the constricted areas of the river, in particular at the lower end of the river at the headwaters of Lake St. Clair. Lake St. Clair generally freezes over in its entirety and is a prime location for winter recreation activities, such as icefishing. The Detroit River is relatively ice free except during thaws or the spring ice breakup period, when ice from Lake St. Clair flows into the river.

Shipping from the St. Clair River to Lake Huron, during the winter months, or vice versa, disrupts the fragil natural ice bridge at the headwaters of the St. Clair River. Whenever this ice bridge collapses, whether it be by natural forces (wind) or by vessel

movement through it, broken ice is permitted to flow into the river and has, on occasion, created flooding in the lower St. Clair River due to ice jamming in constricted areas and retarding the flow in the river. This situation is expected to continue under existing conditions.

As stated before, vessel movement has traditionally occurred in the western end of Lake Erie. The eastern end of the Lake near Buffalo, New York, is a natural constriction and prevailing east-west winds pile large quantities of ice in this area making shipping very difficult, particularly in the spring. Therefore, ship movement is expected to continue principally on the western end of the Lake.

The opening and closing dates of the Welland Canal and its locks are consistent with the corresponding dates of the locks on the St. Lawrence River. Vessel movement through the Welland Canal is expected, as in the past, generally at the end of the 8-1/2 month normal shipping season, to go into or through the Seaway, or go into Lake Ontario ports for winter lay-up. The St. Lawrence Seaway Authority of Canada has plans to extend the season on a long-term basis.

In summary, the "MOST PROBABLE FUTURE" would be commercial navigation on the upper four Great Lakes to 31 January (plus or minus two weeks) in addition to intralake movement on Lakes Michigan and Erie and movement on the St. Clair-Lake St. Clair-Detroit River system which is expected to continue throughout the winter months. Vessel movement would be at the discretion of the shipping companies and largely dependent upon the severity of ice and winter conditions in the connecting channels as well as in the ports of origin and destination. Existing icebreaking assistance would continue.

The Welland Canal and its locks and the St. Marys Falls Canal Locks are expected to remain open to shippers only to meet the reasonable demands of commerce to the extent that weather and ice conditions permit.

Navigation on the St. Lawrence River would cease when, in the judgment of the Seaway operating entities (St. Lawrence Seaway Development Corporation-U.S., St. Lawrence Seaway Authority of Canada) ice and weather conditions preclude safe and efficient navigation on the St. Lawrence River. It is a long-standing U.S. policy and part of specific U.S./Canada agreements that operation of power works, and specifically the ice booms installed yearly on the river by the power entities, should not interfere with navigation.

EXTENDED NAVIGATION SEASON PROBLEMS

Understanding the problems and needs associated with the proposed extension of the navigation season provides a guide to formulation of alternatives to satisfy these problems and needs. Engineering problems identified thus far in the study are geographically described below, starting with a description of the system problems and then proceeding specifically from Lake Superior and working down through the system. Social and environmental impacts of winter navigation are mentioned in this section of Appendix A, but are discussed in detail in Appendixes H and F of this report and in the Environmental Impact Statement. Because of a lack of environmental baseline data for the winter months, the Environmental Plan of Action (EPOA) is proposed to assure that this data will be available for use in preparing the environmental impact statements for each project site. The details of the EPOA are set forth in Appendix E to this report.

System Problems

Icebreaking assistance to meet the demands of year-round extended season commerce on the entire system is a major problem.

Currently, varying degrees of assistance to ships navigating in ice are being provided throughout the Great Lakes by the U.S. Coast Guard and the Canadian Coast Guard. This assistance ranges from radio and radio facsimile broadcasts of up-to-date general information on ice conditions to detailed advice on routing to ships proceeding independently and, finally, to the provision of icebreaker escort if available and considered necessary.

Twelve Coast Guard vessels have been engaged in past years in icebreaking activities. This total included five 180 foot buoy tenders and five 110 foot harbor tugs which were not designed primarily for icebreaking. In addition, the MACKINAW, an icebreaker designed for the Great Lakes, and a polar class icebreaker have been assigned to the Great Lakes fleet to assist in extending the navigation season under the Demonstration Program. The Coast Guard is currently in the process of replacing the 110 foot class vessels with new 140 foot class vessels which have greater icebreaking capabilities. Two of the new vessels have recently been launched; the remainder may be in operation in time for the 1979-1980 winter season. However, additional icebreaker capabilities would be required under a permanent extended season program.

Icebreaker mooring improvements at selected harbors are also needed. Two changes have been required at existing Coast Guard mooring facilities as a result of the Winter Navigation Demonstration Program. The assignment of the second major icebreaker (WESTWIND) to the Great Lakes has resulted in the lease of mooring facilities in Milwaukee, Wisconsin. Leased mooring facilities have also been

acquired in St. Ignace to base one major icebreaker which will maintain traffic flow through the Straits of Mackinac throughout the winter. Additional facilities would be required to accommodate an expanded icebreaker fleet for year-round navigation.

Collection and dissemination of real-time ice and weather conditions throughout the entire Lakes-Seaway system is a problem associated with extended-season operations.

The U.S. Coast Guard has established an Ice Navigation Center (INC) at the Ninth Coast Guard District Headquarters in Cleveland, Ohio, to collect data on ice and weather conditions on the Great Lakes from all available sources, compile and analyze it, and disseminate this information to merchant vessels, icebreakers, interested government agencies, and the general public. The INC begins full-time operation in December most seasons and operates to April. Throughout the extended navigation season, Ice Forecasts, Ice Outlooks, Ice Charts, and Wind and Temperature Forecast Charts are disseminated daily, Ice Condition Summaries weekly. All informational items are available to interested parties from the INC and from Coast Guard Group Offices in Detroit, Milwaukee, Duluth, Buffalo, and Sault Ste. Marie. Most Coast Guard Stations provide Ice Forecasts and Outlooks. Ice Charts and Wind and Temperature Forecast Charts are broadcast by the Loran Radio Network.

Coast Guard personnel from U.S.C.G. air stations in the Great Lakes make regular visual reconnaissance flights, draft ice charts, and transmit graphic and teletype ice cover information to the INC for operational use. As side-looking airborne radar (SLAR) and satellite data became operational, the number of visual reconnaissance flights were reduced and SLAR and satellite information became a significant source of ice cover data during the Demonstration Program.

Complete weather forecasts are now carried throughout the year. The number of forecasts released has increased about 30 percent. Wintertime forecasts are more difficult and time consuming because forecasters must assess the effect of ice cover on wave development. Forecasters must also direct more attention to connecting waterways and narrow channels where weather problems are minimal in summer.

Traditional breakup forecasts have been complicated by the need to assess the effect of icebreaker and other assistance to early season navigation. Similar problems are encountered in preparing freeze-up forecasts.

During the season of active operations in ice, twice daily forecasts and thrice-weekly graphical analyses of current ice conditions are released. Thirty-day and ninety-day graphical outlooks for ice cover are released periodically. Special forecasts were made daily for the Sugar Island ferry operations.

An observational network has been developed to bring the required data to the forecast office. Much of the data currently used is that collected by other agencies in carrying out their assigned portions of the Demonstration Program. Included are direct measurements of ice from shore stations and ships, aerial reconnaissance, side looking airborne radar (SLAR) imagery, and satellite data.

All worded forecasts are now transmitted by teletypewriter, and all graphical forecasts by facsimile. Many of the observations are gathered via the same channels. This improved communications network is an essential part of winter navigation.

All-weather aids to navigation are necessary for ships to accurately determine position in the open lake. LORAN C is the government sponsored navigation system for the U.S. Coastal Confluence Zone, including the Great Lakes. Upon completion in July

1980, the mariner will have a year-round navigation system in addition to the existing system of major lake coast lights, radio beacons, fog signals, and Radar Transponder Beacons (RACONS), which is considered adequate for the Great Lakes. However, a more precise all-weather aid to navigation is considered necessary for the St. Lawrence River.

Currently, during the winter months, Masters of ships are cautioned that most of the conventional buoys are removed and many are replaced by marker buoys. Similarly, the charted or listed characteristics of lights and position of buoys should not be relied upon due to weather and ice conditions. Particular vigilance is therefore required in the navigation of vessels during the winter season. Close attention must be paid to "Notice to Mariners", "Notice to Shipping", and safety broadcasts.

Improved floating aids systems are still required for marking channels, not only in the Connecting Channels but also harbors. Experimentation with new types of lighted and unlighted floating winter markers has met with varying degrees of success.

The introduction of winter navigation on the Lakes will produce a need for surface and air capability to respond to incidents involving major vessels year-round. Search and rescue needs also require adequate surface and air capability to respond to incidents involving major vessels year-round. All-weather aircraft are required for rapid assistance needs.

With regard to hazardous substance spills, the same institutional framework and contingency plans are operational, winter or summer, to ensure an immediate response should a pollution emergency develop. To date, no significant spills have resulted from winter navigation. As a mitigating factor, ice cover and cold water may tend to lessen dispersions of hazardous materials should an accident occur under

extended season conditions. Mechanical improvements are currently being developed to increase the capability of handling spills in the winter. At present, there is little evidence to support claims that hazardous cargo transport is inherently more risky in the winter. The converse is also true. Each spill, winter or summer, presents unique circumstances and difficulties with personnel and logistics. Problems associated with spills in the Connecting Channels are much more complicated than spills in calm lake waters because of the inability to contain a spill in the fast flowing waters. This would be a problem in summer as well as winter.

Vessel waste discharge is currently assessed under existing Federal and state regulations. Waste water is defined as water in combination with other substances, including ballast water and water used for washing cargo holds, but excludes water in combination with oil/hazardous polluting substances or sewage. Existing agreements with Canada preclude waste water from being discharged by a vessel into waters of the Great Lakes in amounts or in concentrations that will be deleterious. The Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977 regulate blackwater discharge. Both new and existing vessels must comply with Federal regulations (treatment or holding of blackwater wastes) by 30 January 1980.

The Clean Water Act of 1977 defines sewage as human body waste and the wastes from toilets and other receptacles intended to receive or retain body wastes except that, with respect to commercial vessels on the Great Lakes, such term shall include graywater, which is galley, bath, and shower water. This Act further states that the EPA Administrator shall, with respect to commercial vessels on the Great Lakes, establish standards which require at a minimum the equivalency of secondary treatment as defined under Section 304(d) of the Act. Such standards and regulations shall take effect for existing vessels after such time as the Administrator determines to be reasonable for the upgrading of marine sanitation devices. Modifications specifically oriented to winter navigation are not deemed necessary.

Vessel traffic control would facilitate convoying and icebreaking. Regular voyage reports (at calling in points) would be required from all vessels wanting convoying assistance except those on a scheduled run (ferries). These reports would have to be rapidly assessed and correlated with forecast ice conditions to form convoys and dispatch icebreakers. These procedures would be more formalized than those currently used for setting up convoy departures.

There are two basic vessel reporting systems in use on the Great Lakes for Ice Navigation purposes. One is U.S. in origin, the other Canadian. The U.S. system is designed solely to provide vessel traffic information to aid in the efficient deployment of icebreaking resources. The purpose of the Canadian ship reporting system is to provide marine traffic information to meet the requirements of the St. Lawrence Seaway Authority and the Canadian Coast Guard Traffic Centre, Sarnia (CCG Traffic Centre). Traffic information so obtained during the ice season is forwarded to the Canadian Coast Guard ice operations office--Ice Toronto--to aid in the preparation of ice information, routing advice, and in the assignment of icebreaker support. The CCG Traffic Centre does not directly provide ice navigation advice to shipping.

During the Demonstration Program, existing Coast Guard communications facilities have been able to handle the reports from the relatively few vessels operating. Considering the projected traffic, an automated system and additional radio operators will be required in an expanded operation.

Radio communications play an important part in successful ice navigation. The Master relies upon the receipt of accurate ice information and advice upon which he can base his decisions as to his future course and progress. Effective icebreaker support and

assistance to shipping also requires reliable radio/telephone (R/T) communications.

Vessel traffic services (control) are not considered necessary on the open lakes to prevent collisions, rammings, or groundings. In areas such as the west Basin of Lake Erie, which are open lake but extremely shallow, the Lake Carriers Association/Dominion Marine Association (LCA/DMA) tracklines have provided an acceptable means of traffic control.

Much research into safety and survival systems has been undertaken as a result of the Demonstration Program; a tangible action to date is the Coast Guard's recent approval of two survival suit types for merchant seamen. However, the anticipated survival time of a man immersed in extremely cold water is still very brief.

New measures should require the provision and use of improved and new cold water survival equipment on vessels navigating the Great Lakes during the winter months (December thru April). This equipment would include:

a. Personal survival suits for all crew members.

b. Enclosed lifeboats/capsules capable of being launched with all personnel aboard and equipped with diesel engines designed to function in sub-freezing temperatures.

c. Emergency Position Indicating Radio Beacons (EPIRBS) on all vessels and lifeboats/survival capsules.

Mandatory crew training in cold water survival techniques should be required and should be conducted annually just prior to the winter

season. All costs to be incurred would have to be borne by vessel owners and operators as part of their general safety program.

The Coast Guard has an ongoing research program to develop hardware to provide for the above safety needs. At this time, most portions of the program are under review by Coast Guard Headquarters prior to presentation to Congress. If desirable, legislation will be needed to make these safety items mandatory for vessels operating in the winter.

The U.S. Coast Guard has assessed from experience that any sheltered location which provides a lee from winds and wind generated seas may be termed a refuge area. Ice cover greatly reduces wave action, and many areas are completely frozen over. An ice field, in itself, is a refuge area and can provide a wave calming haven for any vessel in the area.

Many vessels in the existing Great Lakes fleet, such as the modern 1,000 foot bulk carriers, have the structural and power capabilities to operate in ice; however, the need for additional ice strengthening does exist in some cases in order for the Master to utilize all available power without a high risk of causing vessel damage.

The first principle of successful ice navigation is to maintain freedom to maneuver. Once a ship becomes trapped, she tends to go wherever the ice goes. Ice navigation requires great patience and can be a tiring business with or without icebreaker escort. The long way around a difficult ice area whose limits are known is often the fastest and safest way to port--or to open water.

Experience has proved that, in ice concentrations, three basic ship handling rules apply:

(1) Keep moving--even very slowly, but keep moving.

(2) Try to work with the ice movement and not against it.

(3) Excessive speed means ice damage.

The propulsion plant and steering gear of any ship intending to operate in ice must be reliable and capable of a fast response to maneuver orders. The navigational and communications equipment must be equally reliable, and particular attention should be paid to maintaining radar at peak performance.

Light and partly-loaded ships should be ballasted as deeply as possible, but excessive stern trim is not recommended, since it cuts down maneuverability. Traditionally, operation of ships light in the bow has been effective in the spring, since most ice encountered was unbroken and generally of uniform thickness. However, in a brash-filled channel, operating with shallow draft forward is not effective. The best trim for negotiating a brash-filled channel is with the bow down, if practical. Suction strainers should be able to be easily removed and cleared of ice and snow. Good searchlights should be available in the event of night navigation with or without icebreaker escort.

Experience has shown that non ice-strengthened ships with an open water speed of about 12 knots often become hopelessly beset in relatively light ice conditions, whereas an adequately powered ice-strengthened ship should be able to make progress even when ice coverage is 60 to 70 percent. Adequate horsepower is generally considered to exist when the horsepower to length ratio (not just raw horsepower) is six to one or better, for example 6000 hp divided by 750 ft. These ships are often able to proceed independently without any assistance other than routing advice. When negotiating brash-filled channels, this ratio becomes most significant. Again a six to one ratio indicates the ship will manage quite well. Ships with horsepower to length ratios of less than six to one should be prepared for delays, depending on ice conditions and availability of assistance. Ice conditions should be carefully evaluated before planning a trip in a low powered vessel.

A real concern is the removal of wrecked or stranded vessels. This could occur in any of the improved navigation channels and harbors or in confined areas that have not required improvements within the Great Lakes and St. Lawrence River system.

These situations are very difficult to anticipate and predict. Each casualty is unique. What sometimes appears as a relatively simple grounding can conceivably result in holing the vessel and flooding of one or more compartments, requiring temporary repairs, pumping, and even lightering of a large portion of the cargo in order to pull the vessel free. When lightering is required, this creates the further problem of getting another vessel or lighter alongside to accept part of the cargo.

In the case of a vessel sinking or blocking a navigational channel during the winter months, the remedy for the problem becomes much more time connsuming and costly. Should an oil spill result, salvage efforts could be further delayed as the U.S. Coast Guard is

called in to handle this responsibility. If a serious accident occurred in certain critical areas of the Connecting Channels, obstructing the channel, then it might be necessary to suspend winter navigation through that area until the obstruction could be cleared.

Lake Superior

In open lake areas, windrowing, rafting, and shifting ice conditions continue to be a problem. As the ice cover moves and changes, it closes old vessel tracks and forms rafts and ridges that may reach a height of 25 feet in some areas.

The seven major harbors in Lake Superior are shown in Figure 3. Ice problems and conditions relating to winter navigation are described below.

Taconite Harbor, Minnesota, shown in Figure 3 is a private harbor, located just to the northeast of Two Harbors. Prevailing westerly winds and a northeast shore current tend to keep the harbor and surrounding area open much of the winter, making this an excellent year round harbor. Ice thickness rarely exceeds four inches in the harbor and docking areas. Year-round navigation has occurred there since 1973-74 without experiencing serious problems. At present, only taconite is shipped out. Incoming coal shipments are curtailed during the winter months because the wet coal tends to freeze into lumps, making handling very difficult.

Silver Bay, Minnesota, is a private harbor, located about 26 miles southwest of Taconite Harbor. The harbor is privately owned by the Reserve Mining Company and used primarily for incoming shipments of coal and outgoing shipments of taconite. There is only one dock in Silver Bay, which forms the northwest side of the harbor. The dock is immediately inside the harbor entrance so there are no navigation channels. The navigation season generally ends about

15 January because of the ice problems elsewhere on the ship routes. The harbor generally contains open water until about 15 February. Ice thickness during the severe winter of 1976-1977 reached 14 inches but usually does not exceed six to eight inches. Shifting winds usually break up the harbor ice cover by wave action while prevailing westerly winds keep the broken ice flushed from the harbor. Occasionally, it has been necessary for the U. S. Coast Guard to break up the harbor ice prior to the start of the spring shipping season, but usually all ice is gone by 1 April.

Two Harbors, Minnesota, is used primarily to ship out taconite pellets. The predominant northwesterly winds tend to blow lake ice away from the outer harbor area, keeping the area open most of the winter. In recent years, during extended navigation season operations, a tug was used to break ice in the harbor and clear it away from the face of docks. Wind would normally blow the loose ice out of the harbor and into the lake. There do not appear to be any significant problems to hamper winter navigation at this location.

Duluth-Superior Harbor is one of the most important on the Great Lakes and the Nation. While providing excellent protection from summer storms, it is a poor winter harbor. Its shallow depth and the prevailing cold temperatures cause rapid and very heavy ice growth. The lake area outside of the harbor is subject to wind blown rafting ice that frequently extends out for several miles. (The thickest, most difficult ice to transit exists at the lake edge of the windrowed ice.) Navigation through the harbor and approaches is very difficult for even ice breaker type vessels. Within the harbor, ice forms early and may grow to 30 inches in thickness. In spite of the recent emphasis on extending the normal navigation season, the ice conditions within the harbor during the late winter have prevented full success. There was no intent, however, in the Demonstration Program to prepare a system--or even complete a harbor opening plan to keep a harbor open during winter.

Ashland Harbor, Wisconsin, is about 60 miles east of Superior-Duluth Harbor in a relatively well protected but shallow bay. Ashland experiences the coldest weather of any harbor on the Great Lakes. Because of its shallow depth, the harbor freezes over rapidly early in winter and develops a very heavy ice and snow cover that makes Ashland the most difficult harbor in the Great Lakes to keep open for year round navigation. At present, the harbor is closed in winter. During the regular season, the harbor receives eastern coal for its local power plant. Limestone is the only outgoing commodity which is not normally shipped in winter because of its high moisture content. It is anticipated that maintaining an open channel will be difficult because the broken ice would remain in the channel and refreeze after vessel passage. It is also anticipated that local ice fishermen will protest cutting channels through Chequamegon Bay which, at the least, would reduce their access to many fishing areas.

Presque Isle Harbor, Michigan, is a well protected harbor which currently maintains a level, stable ice cover through the winter that can reach 30 inches in thickness. There is no winter navigation in this harbor. With the exception of maintaining an open vessel track into the harbor, no winter navigation problems are anticipated.

Marquette Harbor, Michigan, is near Presque Isle Harbor and has similar ice conditions, in that a stable ice cover is prevalent in and around the harbor area. With the exception of maintaining a vessel track into the harbor, no winter navigation problems are anticipated.

St. Marys River

Vessel traffic control in the St. Marys River for prevention of collision, rammings, or groundings is provided by the U.S. Coast

Guard. With upbound and downbound vessels using Middle Neebish Channel under alternating direction one-way traffic, no additional facilities are required. If concurrent two-way traffic is needed in Middle Neebish Channel, closed-circuit television (low light level) will be required to monitor conditions and preclude meeting at Johnson Point and Stribling Point. There are several problems associated with winter operations at the St. Marys Falls Canal (Soo Locks). The condition of ice upstream of the lock entrance is generally broken and fragmented from the action of wind, current, and ship traffic. Each time the upper gates are opened, delays result from the ice concentration. Often ice must be manually pushed out of the gate recesses, or the gate is operated in a fanning procedure by incremental opening and closing to remove ice, before the gate can fully open.

Considerable effort is required for winter lock operation and ships are detained due to the delays in opening the gates. This problem further compounds locking procedures because the vessel bow, on entering the lock, plows the ice ahead and sometimes fills the lock chamber. This also can prevent the ship from entering the lock. The ship must then be backed out and the locked ice is flushed and locked downstream. Air bubblers help in preventing ice build-up in gate recesses; however, they do not prevent moving ice from packing in the gateways and, though helpful, they do not completely solve the problems.

Ice accumulates in the upper lock entrance and is passed through the lock chamber ahead of ships entering the lock. Once flushed downstream, the flow carries the ice until the current decreases. All the ice then lodges about 500 to 1,000 feet downstream of the lower gates in Soo Harbor. This situation occurs particularly after surface ice forms in the lower pool area, which in turn hinders flushing ice further downstream and out into the harbor. The build-up of slush ice and fragmented ice solidifies to depths up to

20 feet. This barrier, on occasion, has become impenetrable by cargo vessels and must be broken by a large icebreaker such as the MACKINAW and flushed as far downstream as possible. Once this condition occurs, usually by mid or late January, the condition rapidly develops again, creating an ongoing problem throughout the winter. At about the same time the larger width ships find it difficult to near impossible to lock through as the ship's hull and bow plows the slush ice and plasters the approach walls with ice, which readily solidifies. The ice on the walls can reduce the essential lock width to a dimension less than the hull of the ship, rendering entrance nigh impossible. Such conditions result in tremendous stress-strain loads in the ship's hull and the lock wall monoliths and gate structures. The problem of ice on the lower approach walls and entrances is one of the most severe conditions encountered.

The intense cold temperatures of January and February reduce the steel temperatures of the lock gates below freezing. The alternate filling and emptying cycle in the lock chamber adds ice coatings to the colder gate and severe icing conditions occur. Accumulated ice coatings on the upstream gate backing timbers and gate skin is sufficient to prevent complete and ready opening of the gates. Gate areas that have troublesome ice buildup are steamed free. Ice also accumulates in the open face (downstream side) of the upper and intermediate gates. Pieces of broken ice and slush are pushed in the open side by passing ships. Repeated occurrences load the gates with a loading that tests the structural strength of the gates when the chamber is at low pool. Structural failure of the gate could result if corrective measures are not taken. The operating gate furthest downstream has the least problems with the downstream open face icing since it is only exposed to the lower pool level. However, this gate has the most problems with the closed or skin plate side since it is exposed to the frigid air on the open side with alternate wettings on the skin side. This results in rapidly forming ice coatings and associated opening problems. The dewatering gates, maintained in the

open position during navigation period, fill with ice between girders. This ice is difficult to remove and requires steaming after navigation is stopped, in order that the gates may be closed and the lock dewatered.

Fender replacement and repair work in the lock wall and pier areas that are used in the extended winter navigation season must be accomplished between vessel transits. This is an inefficient, slow process requiring many man-hours to accomplish. The busier the lock the less the fender work that can be accomplished. Because of ice build-up on the walls and timber fenders, wall coating or scraping is necessary. The timber fender wear and tear is increased at times when this scraping activity is done by tug. The impact of winter navigation is that of greater than normal fender wear, tear, and damage while providing less time to accomplish the necessary repair and replacement program.

During winter operation, alternate submergence and exposure to atmospheric conditions plus the actions of entering or leaving vessels build up an ice collar on the vertical walls of the lock near the high water zone. The ice collar dimensionally is two to three or more feet thick in width, five to seven or more feet in vertical dimension and extends the full length of the locks. Large vessels, those 105 feet in width, under the best of conditions only have a clear dimension of 2.5 feet on either side of the vessel in the Poe Lock. The lock wall ice build-up restricts the larger vessels from transiting the Poe Lock. The ice collar build-up not only tends to restrict the transiting of a vessel, but also slows the movement of drift ice into the lock chamber as a vessel is entering, or when ice is being locked through to clear the upper approach.

During the Demonstration Program, the MacArthur Lock has handled vessel traffic later in the season and opened up for traffic earlier in the spring. Drift ice conditions tend to be worse in the spring

and separate lockages are often required to lock ice through prior to transiting a vessel. The Poe Lock is the primary winter navigation lock and, because of its size, can accept a 75 foot wide vessel and connsiderable ice in the lock chamber, at the same time, without encountering substantial locking problems. It is anticipated that a larger number of 105 foot wide vessels will operate during any extended winter navigation season in the coming years, and ice removal from the lock will become a major problem. The problem of removing ice from the lock becomes intensified when the area from the lower lock approach to Angle Course 1-2 becomes filled with ice.

During the Demonstration Program, the MacArthur Lock's operational season has been extended, subjecting the lock equipment to winter navigation conditions. From the experience gained in the Demonstration Program, it is known that increased malfunction will occur and increased maintenance will be required on all equipment utilized during a winter navigation season.

The Poe Lock is the principal winter navigation lock and will continue to experience the maintenance problems previously stated. As the lock equipment ages, increased malfunction may be expected and additional maintenance operations will be required for the lock gates, operating machinery, filling and emptying valves, and fender booms.

It is assumed that abrasion on the lock walls will accelerate as more vessels and wider vessels travel during winter navigation. The 105 foot vessels tend to force the moving ice into and along the wall surfaces. Wearing of the vinyl painted gate surfaces will be accelerated by packed, moving ice.

Operation and repair of the locks during winter conditions and maintenance and/or repair of ice control facilities require the operation of Corps of Engineers tugs, derrickboats, and gatelifter. To perform these functions during winter navigation requires that the plant be capable of effective and safe operation in ice covered waters.

Traditionally, the winter lay-up period had been utilized to perform annual repairs and major overhauls to the tugs and derrick-boat. With the advent of winter operation, the wear and tear on equipment has been accelerated, and because the plant must be on stand-by status, opportunity to perform major repairs or overhauls has been severely curtailed.

During the Demonstration Program two tugs have been used extensively. They are the 65 foot Tug OWEN M. FREDERICK, powered by a 250 hp direct reversing engine, and the 45 foot Tug WHITEFISH BAY powered by a 340 hp engine with reverse gear. The use of these vessels has been necessary to perform the following:

a. removing ice from pier fenders in the lock approaches,
b. removing packed ice from lock guard gates,
c. assisting in removal of the ice collar in the lock chambers,
d. loosening pack ice in the lock approaches,
e. loosening ice from Little Rapids ice boom timbers, and
f. towing and maneuvering the derrickboat during ice boom repair operations.

In addition, in the event of damage or failure of lock operating machinery, such as gates, pumps, valves, or safety booms, it is required that the tug or tugs be available to maneuver the Derrickboat HARVEY and/or Gatelifter PAUL BUNYAN to make repairs as necessary.

These tugs were not designed for ice operation. The problems encountered and to be corrected are: (a) the bow of the FREDERICK should be of an icebreaking design and both tugs require heavier bow framing and plating; (b) the main propulsion power of the FREDERICK must be increased considerably; (c) the steering gears of both tugs must be strengthened; (d) the sea chest and cooling water supply on the WHITEFISH BAY must be modified to function in broken ice conditions; and (e) the fuel tanks of both tugs must be isolated from the hull plating to provide for environmental safety.

The Derrickboat HARVEY (120' x 40' x 8'), with air powered spuds and deck machinery, has been utilized for emergency repairs in the lock area and at the Little Rapids ice boom during extended navigation conditions. Problems anticipated are: (a) freezing of spud walls; (b) freezing of clutch and brake machinery; (c) frozen air lines; and (d) unreinforced hull framing and plating damage.

It has not been necessary to date to activate the steam powered Gatelifter PAUL BUNYAN during the extended navigation season; however, for a permanent program, it is considered necessary. Problems similar to those of the derrickboat are expected. These problems can all be corrected by vessel modification.

The improved channels are maintained by sweeping to project depths and removing located strikes and shoals with derrickboats. This operation is performed annually in hard bottom channels and in soft bottom channels where they are susceptible to shoaling, including the approaches to the locks which are cleared of projections above project grade each season. Those high spots removed are usually minor in height (0.5 foot or less above grade).

Since the winter season of 1970-71, extra shoal removal operations have been required each spring to restore the west lock approach to project depth. The shoaling which has occurred has been as much as 2.8 feet above project depth. The west approach channel

was constructed by drilling, blasting, and dredging through sandstone bedrock. Considerable rock was broken and loosened by blasting which was not removed in the dredging process because it is below grade. During winter navigation, the west approach channel is ice covered and the steamer track becomes filled with broken ice. In order for vessels to travel through the ice, it is necessary that they use considerably more power than is required in open water conditions. The force of the propeller wash apparently moves the loosened, broken rock from below grade into "windrow" shaped shoals which are built up to elevations above grade. It is necessary to remove the rock shoals to project grade before ships loaded to summer drafts are allowed to transit the channel. Shoal removal operations commence as soon as ice conditions alleviate enough to allow derrickboats to work in the area. As the majority of loose rock is removed, this problem would lessen.

Similar conditions have developed in other reaches of the St. Marys River system. The most significant of these reaches is the Middle Neebish Channel, which is used for both upbound and downbound traffic during the winter navigation season. The impact of winter navigation on these channels is estimated to be one and one-half times that of the impact to maintenance operations in the west approach channels. Therefore, the total impact of bottom scouring in the St. Marys River during the winter navigation is estimated to be 85 (34 x 2.5) additional days of channel maintenance work.

Generally, the St. Marys Falls Canal control and dispatching is efficiently and expediently performed by a Chief Lockmaster on duty in the canal tower. Dispatches are made by radio FM WUD 31. Ships reported downbound or upbound are received in the tower through a land phone from the U.S. Coast Guard. Policy is that of "first come-first serve." This is adhered to unless extreme extenuating circumstances prevent that normal procedure. This policy and operation is proven and is satisfactory to the users.

On occasion, when a large carrier appears for lockage, experience has shown that a lengthy lockage delay may result. Therefore, consideration has been given to a lockage sequence other than "first come-first serve." To expedite shipping, it may be a better choice to lock through first the ships less than 105 feet wide provided they are in the same convoy. These ships do not coat the walls with ice, and lockage is easier. Any delays experienced with the large ship would not then delay the other ships. Other considerations that remain critical to the judgement of the Chief Lockmaster are horsepower of the smaller ships, locking experience with the wide ships, existing ice conditions, ice tracks available, ability to pass, etc. The basic policy of "first come-first serve" should prevail except when delays are predictable. Two large super-class vessels locking in sequence, without an interval to eradicate or remove snow conditions during the winter period, has created additional safety hazards along pier and lock work surface areas.

It has been observed that ice build-up on the sides of the vessels moving along the piers sometimes will fall off and shatter over the work and walk area, causing possible hazards to lock personnel. In addition, wind blown snow overhangs the pier edge, causing a hazard for those who have occasion to walk to the pier's edge.

Removing the ice collar caused by winter navigation is accomplished by use of steam where it is available. Other methods of removing the ice collar are using a backhoe and chipping with the bucket or modified ripper, or using a tractor operated ice cutting chainsaw. All of these methods of ice collar removal present additional hazards to lock personnel.

It is difficult and time consuming to close the lock gates at times during winter navigation. This creates a problem in event of an injury where the person would have to be brought across the lock.

Personnel involved in outside work are sometimes working in extremely adverse weather conditions and are subject to frostbite. Appropriate clothing and safety gear are needed.

Winter navigation poses additional difficulties in event of a man overboard. Injury is more probable because of floating ice in the water. The water temperature is such that a man would not likely be able to do much for himself even though he had a life vest on. These conditions pose additional problems in accomplishing rescue operations.

Winter navigation poses additional problems in regard to gasoline and alcohol storage in the lock area. Gasoline is required for snow removal and alcohol for thawing frozen air bubbler systems.

Experience has shown that winter navigation promotes circumtances that increase diving operations. This requires divers to work below an ice cover and be exposed to cold weather when they surface. Other problems are with freezing and icing of diving equipment.

Manpower requirements for Lock Operations and St. Marys River floating plant of the Soo Area were greatest during the regular navigation season and least during the closed season. With winter navigation, changes in employee work and vacation schedules have been and would be necessary.

Proceeding downstream from the locks, the ice cover in Soo Harbor and the ice bridge above Little Rapids Cut can break naturally under high winds or thaw conditions and move downstream, sometimes causing ice jams in Lower Little Rapids Cut. The continual movement of vessels during the winter increases the amount of broken ice that could jam in Little Rapids Cut and subsequently cause disruption to

the Sugar Island ferry. When either the ferry track becomes filled with ice, or when ice builds up in the mainland ferry slip, the ferry is unable to operate. A strong cross current on the island side normally keeps the island slip clear of ice. There is no cross current on the mainland side and drift ice entering the slip can make landing difficult or impossible.

Occasionally, Coast Guard icebreaker assistance was required to provide temporary ferry service to island residents and also to breach ice downstream of the ferry crossing before a new ferry track could be re-established. For a navigation season to 31 January (plus or minus two weeks), which has been recommended in the March 1976 Interim Report, an ice boom was recommended at the head of the Cut; however, for year-round operation, additional ice stability measures are contemplated. Also recommended was a bubbler-flusher system at the mainland dock.

Loose ice passing through the boom opening, snow, slush, and frazil ice tend to collect in the slower velocity areas at the lower end of Little Rapids Cut and in the upper end of Lake Nicolet. Repeated ship traffic through this area causes the ice to compact and layer and to form thick ridges within the navigation channel which have exceeded 15 feet in thickness. Some vessels, particularly those underpowered or the lighter, upbound ships have difficulty in transiting the two to three mile reach where the jam occurs.

The Neebish Island ferry currently stops operating when ice begins to develop. Accessability to the mainland resumes when the ice becomes thick enough to support foot or snowmobile traffic. At this time, downbound vessel traffic is diverted to the Middle Neebish Channel and does not disrupt normal access to the island. If the West Neebish Channel is used for future winter navigation, the island will be isolated from the mainland, which will create access problems.

A particular problem in the Middle and West Neebish Channels is that neither channel can accommodate two-way traffic without a control mechanism. During the summer months, the Middle Neebish is used as the upbound channel and the West Neebish is used as the downbound channel.

With the advent of winter navigation, a ship track cuts through the stable ice cover between inhabited Lime Island and the Michigan mainland, destroying the ice cover access which was historically used. For a navigation season to 31 January (plus or minus two weeks), which was recommended in the March 1976 Interim Report, an airboat sled would be needed to provide islanders access.

Access to Drummond Island is provided year-round by a ferry across the mile-wide DeTour Passage. Historically, ferry operations have been hampered by wind blown ice. Ice can be blown north from Lake Huron and jam against the stable ice bridge which normally forms across the Passage upstream of the ferry crossing. Northerly winds tend to clear the Passage south of the ice bridge, but frequently, loose ice is blown along the shoreline at DeTour and/or Drummond Island. This ice tends to compact in the ferry landing slips and hampers the ferry from docking.

There is a pilot transfer point at DeTour, Michigan, where the St. Marys River empties into Lake Huron. The pilots are transferred by an old fishing tug that is not capable of winter operations. An improved vessel would be required for a year-round extended season on the entire system. Only ocean going vessels normally require pilots, and lake vessels would present no problem.

Commercial navigation through the solid ice fields in DeTour Passage does not affect its overall stability. Some loose ice is dislodged, however, at the edge of the ice bridge along the

navigation track, which may add to the difficulty of ferry operations. The severity of this effect would continue to be monitored. Winter navigation during the Demonstration Program has interfered with the alternate mode of transportation to Drummond Island. Snowmobiles could no longer safely utilize the stable ice bridge north of the ferry crossing because of the vessel track which is re-opened with each passage.

Since winter flows have been limited to a maximum of 85,000 cubic feet per second (cfs) by international agreement, there have been no serious flood threats in Soo Harbor.

In January 1971 there was one test whereby winter flow was increased to 91,000 cfs. An ice jam resulted in Little Rapids Cut and levels began to rise rapidly in Soo Harbor, approaching flood stage at the Edison Sault Power Plant. The test involved the emergency de-icing and closing of gates on the control structure. Flows were subsequently reduced, and Soo Harbor water levels dropped to a less critical elevation.

Anchor ice is a problem at all the intake water canals of the three power plants above Soo Harbor. This phenomenon occasionally occurs during periods of extremely cold temperatures. Water entering the plant becomes super-cooled and freezes to the trash racks or the turbine blades, reducing power generation. This problem is temporary in nature, corrects itself, and rarely exceeds 24 hours in duration. Agglomeratic ice, caused by the churning up of ice in the shipping lanes, works its way into the turbine intake and has a tendency to retard the flow of water through the turbines in addition to contributing to the ice jams forming on the downstream side of the power plants. Also, frazil ice is formed during periods of extremely cold temperatures in areas of fast flowing water in the headrace and tailrace of the power plants and open water areas of Soo Harbor. The fast velocity prevents an ice cover from forming, but surface ice is

generated as a form of slush which can build up around intake gates or collect downstream in the slower velocity areas, particularly in the area below Little Rapids Cut. This type of ice is very difficult to navigate through because of its cohesiveness in forming a thick, dense barrier.

Vessel movement during winter is further hindered at the tight turns in the navigation channels of the St. Marys River at eight problem areas, namely: (1) Birch Point Turn, (2) Middle Neebish Channel, (3) Angle Course 5 and 6, (4) Angle Course 6 and 7, (5) Angle Course 8 and 9, (6) Angle Course 9 and 10, (7) Lime Island Turn, and (8) Pipe Island Turn. Because the length of many vessels varies between 600 and 1000 feet, ice cover in the vicinity of a tight turn and narrow channel tends to reduce the turning and maneuvering ability of vessels. Some are equipped with bow thrusters which direct the bow side to side while others have rudder control on the stern. As the vessel attempts to turn, frictional resistance builds up along the sides of the ship. Frequently, Coast Guard icebreakers are required to relieve the resistance by working alongside of the vessel.

Another effect of winter navigation involves increased shoreline erosion and shore structure damage (primarily docks). Shore erosion results from broken pack ice moving in a restricted channel. In ice covered areas along the riverbank, ship-induced disturbances, if large, may shift this ice and gouge the soil and protective vegetation, exposing it to erosion in the summer. Areas of deep near-shore water may be subject to erosion due to moving ice floes and the drawdown effects of passing vessels.

Drift or pack ice and stable ice, have an effect on shore structures. Pack ice, because of the pressures generated by its movement, has been known to destroy shore structures, particularly

those made of wood. Stable ice has a tendency to adhere to vertical piles and piers. Fluctuations of the water underneath the ice cover can lift these structures out of position (ice jacking). The action of passing ships can also contribute to shore structure damage by intensifying these effects. Locations where this effect could be increased by winter navigation include constricted areas on the St. Marys River, such as at Brush Point, Big Point, Sugar Island on Lake Nicolet and Neebish Island Channels.

A severe upstream erosion area in the St. Marys River is Angle Courses 1 and 2 of the Little Rapids Cut. Some structural damage has been observed in this reach. The upper reach of this course passes close to the land along the area known as Mission Point, where the mainland terminal of the Sugar Island ferry and the Coast Guard lookout station are located. The banks south of the ferry are rather low and have been subject to considerable erosion. A few small boat docks are located on the mainland, but most, including a well developed municipal harbor, are located on a side channel separated from the navigation channel by several small islands.

Nine Mile Point on Sugar Island is another identified shore erosion problem area. Recently, some generally successful attempts at protection have been made by placing small riprap along the shoreline in this area. There are no docks here, and shore structures are not subject to damage. The mainland shore along this reach is protected to some extent by the "old dump grounds" of dredged material between the channel and the shore.

Course 5 of the West Neebish Channel has been identified as a problem erosion and damage area. Currently, however, the West Neebish Channel is not intended for winter navigation use and these "natural" problems will not be aggravated by winter navigation activities.

Along the Middle Neebish Channel, Course 6, the shorelines of both Sugar Island and Neebish Island are generally marshy, except for a short reach on Neebish Island. A dike about 6,000 feet long is located on the Sugar Island side of Course 6, beginning at its upstream end. Some erosion is evident along Neebish Island midway along the course.

Along Courses 8 and 9 of the Middle Neebish Channel, both bank erosion and structural damage are evident. The Neebish Island shoreline along these reaches is well developed with a substantial number of docking facilities located between Mirre Point and Johnson Point. Some of the docks are heavily constructed, but many are not.

Sensitive erosion areas (8,000 feet) were identified along the St. Marys as being subjected to true erosion in the March 1976 Interim Report. A recommendation was included in the report for authorization for advanced engineering and design of protective measures for these areas and areas subjected to structure damage. The areas are at Little Rapids Cut, Nine Mile Point, Six Mile Point, Course 6 and Johnson Point of the Middle Neebish Channel. Additional studies by the U.S. Army Cold Regions Research and Engineering Laboratory have been conducted, including a series of observations over an 18 month period ending in November 1978, and additional areas are being considered for protection in this report.

The passage of ships during winter ice conditions can disrupt the regime of both the ice and underlying water systems. Problems associated with ice in direct contact with soil as well as the combined effects of ice and navigation on the hydraulics of the river system may occur.

Large scale navigation during the winter ice season exerts a major influence on river hydraulics. Measurements of near bottom water velocities during vessel passage have shown changes in water movement direction of 180°, with velocities often far in excess of

ambient conditions. This is usually accompanied by obvious sediment transport. In addition, vessel passage and icebreaking activities which "pack" broken ice under surrounding ice cover further constrict the river cross section and may amplify ship-induced disturbances.

Under ice-covered conditions, the ship-induced water level surges observed under open water conditions are partially transformed into a form of closed conduit pressure surge. As this pressure surge (with attendant higher water velocities) approaches the shore it may cause the ice to break at or near the shore, allowing sediment-laden water to spray out onto the ice cover. If an active crack (one which remains broken throughout the season) is present, a nearshore trough in the bottom may be formed by scour at the crack.

Although shore ice may armor the river bank through much of the winter, ship-induced disturbances, if large, may shift this ice and gouge the soil and protective vegetation, exposing it to erosion in the summer. During spring break-up, the artificially high water velocities caused by ship passage may cause a more rapid ice runout than the normally low river velocities.

Once the shore ice has left, the unnatural nearshore profile brought about by ship-induced water velocity and pressure disturbances may be readjusted at the expense of material located farther onshore and ultimately, the river bank.

There is a unique problem that occasionally occurs adjacent to upper Lake Nicolet between Frechette Point and Six-Mile Point. Based on interviews with local residents, it appears that some ships passing through this reach of the river during ice cover conditions transmit vibrations to the shore and shore structures. These vibrations are reportedly severe enough at times to cause structural damage to the buildings. Although this has been reported at several locations within this area, residents at either end of this reach and

in other similar areas on the river have not experienced this problem.

The effects of winter navigation upon recreation stem from the weakening of the ice cover in the channel, which could make the remaining ice cover unsafe for "on ice" activities, such as ice fishing, or gaining access to fishing sites. The predominant group affected is recreational ice fishermen. On the St. Marys River, affected areas include Waiska Bay, Mosquito Bay, Brush Point, Big Point, Sugar Island on Lake Nicolet, Neebish Island on the West Channel, Raber Bay, Maud Bay, and Lake Munuscong on the Michigan shore. The St. Marys River, in addition to providing a channel for the passage of vessels, supports considerable sport fishing, including ice fishing which peaks in late winter. A popular area for this activity is at the north end of the Neebish Island rock cut. In general, ice fishermen avoid areas of heavy vessel traffic. The winter ice surface also provides an avenue for travel by man and animals along and across the river, including snowmobiling for pleasure and transportation to fishing sites. Ice boating, though popular in the region, is rarely practiced on the river due to the roughness of the ice surface. Animals which may traverse the ice include such recreationally valuable species as moose, deer, and bobcat. Considerable ice fishing takes place immediately south of the vessel track in the St. Marys River, above the Soo Locks complex, between Big Point and the mouth of the Waiska River. The largest concentration of ice fishermen is in the easterly portions of Mosquito Bay and Waiska Bay. A few ice shanties have been located within 100 yards of vessel tracks.

Lake Michigan and Lake Huron

Windrowing, rafting, and shifting ice conditions continue to be a problem which frequently hampers winter navigation, particularly in the northern half of the lakes. Icebreaker assistance is often

required to reopen navigation tracks and relieve pressure against the sides of ships. Ships are often grouped in convoys prior to transiting the northern half of Lake Michigan, Lake Huron, and the Straits of Mackinac to facilitate movement through these areas. Shifting ice conditions, particularly along the southern half of Lake Michigan shorelines, create problems at the entrance to the harbors, causing difficulties for vessels entering and exiting the harbors.

There are 14 major harbors in Lake Michigan as shown in Figure 6. Problems relating to winter navigation at each harbor are described below.

Port Inland Harbor, Michigan, located in northern Lake Michigan, is a private harbor owned by the Inland Limestone Company and used primarily to ship out limestone, sand, gravel and crushed stone. Currently, the harbor is closed during the ice season because the nature of stone processing prohibits winter operation. There are no plans to extend the navigation season at this harbor.

A stable ice cover up to two feet thick forms within the harbor. The area outside of the breakwaters is usually ice free due to prevailing winds which breaks up the ice as it forms and blows it south into the lake. Other than the relatively thick ice in the harbor, there are no apparent problems that would hamper year-round navigation.

Escanaba Harbor, Michigan, is situated on the west shore of Little Bay de Noc, which generally freezes to a solid uniform ice cover. By mid-January the ice thickness is usually two feet and stabilizes between two and three feet thick by the end of February. Usually, in early April, the entire ice cover in the bay will move out rapidly, under northerly winds, sometimes within a single day. Year-round shipping has occurred in 1976-77 and 1977-78 with incoming petroleum products and outgoing taconite pellets. In 1978-79 vessels

operated in Escanaba Harbor until mid-February 1979. Then, due to rafted ice, vessel traffic ceased until the end of March. Unless there is frequent ship traffic to keep a broken ice channel open and limit re-frozen brash to less than 12 inches, ships need assistance to transit from the harbor entrance to the dock area. As open water in the vessel track was exposed to cold air, brash ice accumulated in thickness greater than the original ice cover on either side of the channel. Ships without sufficient power have become stuck in this brash ice. Another problem experienced was ice jamming between the ship and the docks, preventing the ship from getting close enough for loading and unloading.

Green Bay Harbor, Wisconsin, has 37 docks located along a 3.5 mile reach of the Fox River, which are used to ship a wide variety of products, including oil, soap, cement, and paper. Navigation into the harbor usually ceases in mid-December and resumes in late March. Ice in the harbor and along the docks generally forms a stable uniform cover about 18 to 24 inches thick. The river ice is weaker than ice in Green Bay due to the chemical effluent from numerous paper companies upstream. The main area of Green Bay usually begins forming an ice cover in December. Northwesterly winds tend to create windrows which become major obstacles to ships heading south towards the harbor. Normal ice thickness can exceed two feet between windrows.

Problems anticipated for year-round navigation include keeping a track open in the harbor and keeping ice away from the docking areas to allow ships to berth. There is also a concern that frequent ship traffic will allow heavy brash ice to form in the broken areas and hamper ship movement, particularly underpowered vessels.

Port Washington Harbor, Wisconsin, located about 29 miles north of Milwaukee, currently operates year-round. The major commodities

shipped include coal, gasoline, and fuel oil. The lake area outside of the harbor is usually ice free due to the predominant offshore winds. The area within the harbor remains open due to the thermal discharge from Wisconsin Electric Power Company. As a result, no ice problems exist which would cause unusual delays to shipping.

Milwaukee Harbor, Wisconsin, is a large port area which includes an outer harbor protected by offshore breakwaters and an inner harbor consisting of the lower reaches of three rivers, two canals, and a municipal mooring basin. A wide variety of products are shipped through the harbor, including non-metallic minerals, scrap metal, coal, gasoline, and cement. During the winter, railroad car ferries, petroleum tankers, and Lake Michigan freighters navigate between Milwaukee and other southern Lake Michigan ports.

The predominant westerly winds tend to keep the western shore of Lake Michigan, including Milwaukee Harbor ice free during most of the winter. Even during a severe winter, ice cover in the outer harbor rarely exceeds 14 inches. Frequent ship traffic keeps a broken path open and refrozen brash ice is generally less than six inches in thickness. As a result, ships experience only minor delays due to ice.

Chicago Harbor, Illinois, has an outer and inner basin. In addition, a lock and controlling work gives access to the north inner basin and the entrance to the Chicago River.

There is considerable tug-barge traffic which utilizes the Chicago River and Chicago Sanitary and Ship Canal. This reach usually remains ice free throughout the winter. At present, only liquid cargo barges operate in Lake Michigan between Chicago Harbor and Indiana Harbor during the winter months. Ice conditions in southern Lake Michigan vary considerably and readily change with shifts in the wind. Ice pieces tend to accumulate along the southern

shore and will temporarily pack up to 15-20 feet thick and extend 20-25 miles out from shore. During these periods, ships experience major problems operating and frequently are beset in pack ice several miles from the harbor entrance. This condition is transient. When winds shift direction or change intensity, the ice pack will loosen and allow shipping to resume.

Calumet Harbor, Indiana & Illinois, is located about 12 miles south of Chicago Harbor on the border between Indiana and Illinois. Commercial navigation occurs on a year-round basis; however, winter navigation primarily consists of tug-barge traffic hauling slag, scrap metal, and steel between Burns Waterway and Calumet Harbor. Iron ore is also shipped to Calumet Harbor from Two Harbors, Minnesota, during the winter. Winter ice conditions are similar to those of Chicago Harbor. Most ice problems occur when northerly winds consolidate drifting ice into packs 15-20 feet thick and extending 20-25 miles from shore. When the wind changes direction or lessens in intensity, the pack will loosen and allow navigation to resume, generally within 48 hours.

The maximum ice thickness in the Calumet River is about six inches and is kept broken by frequent tug-barge traffic. However, in Lake Calumet, the ice can grow to a thickness of two feet, which can cause docking problems for tugs and ships.

Indiana Harbor, Indiana, consists of a man-made inner and outer harbor located seven miles southeast of Calumet Harbor. Currently, tug-barge commercial navigation occurs on a year-round basis between Indiana Harbor and Chicago. The entire harbor, including the canal, is normally ice free due to the thermal discharge from the Inland Steel Company. Ice problems encountered by ships at the harbor entrance are due exclusively to the wind driven pack ice, which can extend up to 25 miles from the harbor entrance. Maximum delays

anticipated are about two days before winds shift direction and/or intensity. This loosens the ice pack and allows navigation to resume.

Buffington Harbor, Indiana, is a private harbor, owned by the Universal Cement Division of the U. S. Steel Corporation. It is generally closed during the winter period mid-December to late March or April. Ice conditions at the harbor entrance are directly related to the general ice conditions in southern Lake Michigan. On-shore winds will temporarily cause ice to pack up to 15 to 20 feet in depth and extend up to 25 miles into the lake. As is typical, the problem is transient and usually lasts up to two days at a time until winds shift or lessen in intensity, allowing the pack to loosen or drift into the lake. Ice within the harbor and docking area forms a maximum three to four inches in thickness and should pose few problems to ships using the facilities.

Gary Harbor, Indiana, is a private man-made harbor developed and owned by the U. S. Steel Corporation. During the years 1974-75, 1975-76, 1977-78 and 1978-79, U. S. Steel ships have operated year-round between Gary Harbor and Two Harbors, Minnesota. Ice problems are similar to other southern Lake Michigan harbors when northwesterly winds temporarily pack ice up to 20 feet thick extending up to 25 miles into Lake Michigan. This condition rarely lasts more than two days at a time. During the last 15 years, these conditions averaged two days in January, four and one-half days in February and seven days in March with an average duration of one and one-half days and a maximum duration of five days. Navigation can resume when winds shift or lessen in intensity. The area within the harbor is relatively ice free due to the thermal discharge from the steel mill.

Burns Waterway Harbor, Indiana, is an artificial harbor on the south shore of Lake Michigan located between the Bethlehem Steel and

Midwest Steel Corporation Complexes on Indiana Port Commission property. Iron ore, which is shipped year-round, makes up 80 percent of the total tonnage in Burns Harbor. Tug-barge operations carrying slag, scrap metal, steel, coal and liquid fertilizer are also conducted during the winter months. The barges operate freely in the harbor. They keep the existing ice cover broken and experience only minor delays due to ice. As discussed earlier, the problems at the ports in southern Lake Michigan are not within the harbors, but are within the 25 miles of wind packed ice at the southern end of the lake. This can cause delays of up to two days before the wind changes direction and/or intensity, and allows navigation to resume.

Grand Haven Harbor, Michigan, located in the mouth and lower portion of the Grand River, is normally closed to navigation from mid-December to late March, until ice has left the harbor. The major impediment to winter navigation occurs during periods when pack ice is blowing towards shore. Broken ice will enter the harbor and build to a thickness of three to eight feet. This condition may exist up to one mile from the lake. Above this point, an ice cover in the Grand River is stable and may reach one to one and one-half feet in thickness. Depending on wind speed and duration, windrowed ice can jam up to 12 feet thick at the harbor entrance. This problem is transient and can persist from several hours to several days.

Muskegon Harbor, Michigan, is located in Muskegon Lake just inland from Lake Michigan. Entrance into the harbor is accomplished through a 200 foot wide channel protected by breakwaters extending out into Lake Michigan. The general navigation season usually ends in late December and resumes in March. Car ferry steamers currently operate on an unscheduled basis during the winter between Muskegon and Milwaukee. Most ice problems are not in the harbor but at the harbor entrance and out into Lake Michigan with wind driven pack ice. The presence of the ice does not prohibit current operations, but it does cause delays until the winds shift and/or lessen in intensity.

Windrows up to 12 feet thick have blocked the harbor entrance preventing ships, including icebreaking vessels, from entering or leaving the harbor. These conditions are dependent on wind conditions, which usually change within eight hours but may last as long as six days. The ice in Lake Muskegon is generally solid and uniform, growing 18 to 24 inches in thickness. The car ferries and barges keep the navigation track open and experience little difficulty in the harbor.

Ludington Harbor, Michigan, is located in Pere Marquette Lake just within the Lake Michigan shoreline. The outer basin in the lake is enclosed by two converging breakwaters. The general navigation season usually ends in late December and resumes in March. Car ferries operate year-round between Ludington and the Cities of Milwaukee, Manitowoc, and Kewaunee, Wisconsin, averaging four transits per day.

Ice problems are similar to Grand Haven and Muskegon Harbors. A west wind will push drifting ice into the harbor entrance. Depending on wind speed and ice size, the ice can extend to the bottom as floating ice floes, brash ice, or as jammed or windrowed ice in excess of five feet thick. A typical jam lasts one to three days but may stay for several weeks. Easterly winds will blow the ice back into Lake Michigan. This does cause problems to winter navigation generally between mid-February to mid-March with maximum delays of 12 hours. In the protected waters of Pere Marquette Lake and the connecting channel, ice can grow to two feet thick with jams and windrows. However, the frequent movement of car ferries and tug-barges keeps the navigation channels open to traffic.

Although ice floes and brash ice are usually present in the docking areas, ship operators indicate they can maneuver their vessels into the docks with a minimum of problems.

There are six major harbors in Lake Huron as shown in Figure 8 and described under Base Conditions. Ice Problems that may affect winter navigation are described below.

Drummond Island Harbor, Michigan, is primarily used to ship limestone, sand, gravel, and crushed rock. It is closed in winter because the wet-wash process used in quarry operations causes the stone to freeze into a solid mass. If the harbor is to be used year-round, a major ice problem anticipated would be keeping a vessel track open into the harbor and dock area. Presently the maximum ice thickness ranges between two and three feet.

Port Dolomite Harbor, Michigan, is well protected by the Les Cheneaux Islands and consequently forms a solid ice cover up to three feet thick in and around the harbor area. Major problems anticipated are maintaining an open vessel track into the harbor, turning basin and along the dock area. Year-round use of this harbor is not anticipated until a dry method for processing limestone is developed.

Calcite Harbor, Michigan, is used to ship limestone during the ice-free months. A stable ice cover up to two feet thick generally forms in the harbor. Outside of the harbor, ice occasionally windrows up to five feet thick. This condition only occurs about four percent of the time. Normally, the outer harbor area is kept open by predominant offshore winds. The major ice problem anticipated will be keeping a vessel track open into the harbor and dock area.

Stoneport Harbor, Michigan, is a privately owned harbor used to ship limestone during the ice-free months. Ice conditions in and around the harbor may vary from level ice up to 18 inches thick to windrowed ice up to five feet thick. The windrowed condition is usually temporary since predominant northwest winds tend to blow the

ice back into the lake. It is anticipated that ships would have problems navigating through windrowed ice and also in berthing close to the dock unless ice is first cleared from the slip area.

Alpena Harbor, Michigan, is closed during the coldest months, January through March. Ice conditions vary from year to year. The harbor and bay are usually open, but southeasterly winds can pack the harbor with ice floes up to three feet thick and cause heavy ice windrows in the bay. This condition may last from a few days to several weeks until offshore winds blow the ice back into the lake. Ships would have difficulty navigating into the harbor or docking during those times when ice fills the harbor.

Ports on the Saginaw River, Michigan, are located along 17 miles of the river at the Cities of Essexville, Bay City, Zilwaukee, Carrollton, and Saginaw. Ice problems are expected to be minor because the river usually remains open, but it may on occasion develop a weak ice cover, generally less than one foot thick. Major problems anticipated are maintaining a vessel track outside of the harbor, through Saginaw Bay, where level ice can exceed two feet in thickness and windrowed ice can build to six feet in depth. In addition, the vessel track through the bay may restrict ice fishing and snowmobiling, popular recreation activities for many people in the area.

Straits of Mackinac

Problems in the Straits are directly related to shifting ice conditions requiring a need for maintenance of a vessel track through the Straits for the vessels to operate in.

Heavy ice conditions in the Straits area would prevent vessels from careening into the Mackinac Bridge abutments. Even in high winds, vessels are more or less held in the vessel track, thus preventing any major mishap.

St. Clair River, Lake St. Clair, Detroit River System

Ice conditions within the St. Clair River have not changed significantly during the period of demonstration of winter navigation. There has not been extensive enough shipping through the ice bridge, which occurs naturally at the head of the river at Port Huron, Michigan, during mid-winter, to determine if significant amounts of ice are added to the system. There have been instances when ships have passed through without affecting the integrity of the ice arch or the ice cover in Lake Huron. A few loose pieces of ice have broken off to drift downstream near the navigation track, but to date, no major ship-caused release of ice has been documented. However, if winter navigation were to continue regularly through the ice bridge area under all types of wind and weather conditions, additional ice could be added to the lower river, causing an increase in the frequency of occurrence of ice jams in the lower river in the vicinity of Algonac, Michigan.

Ice jams have continued to be a problem in the lower St. Clair River, particularly during February 1973 and March 1975 when there was significant flooding in the Algonac-Marine City area. This problem was compounded by the near-record high lake levels that prevailed throughout the system during those years. The ice jams resulted from unusually large quantities of ice that entered the river from Lake Huron after strong winds and thaw conditions broke up the stable ice cover. Southern winds would first blow the ice cover north into Lake Huron, then strong northern winds would blow the broken ice floes back into the river. A solid ice jam formed over the lower river from Lake St. Clair upstream 15-16 miles to Marine City. The northern winds compacted the ice into layers several feet thick in many areas. These ice jams retarded the abnormally high flows such that levels rose upstream and flooded numerous homes in

the low-lying areas adjacent to the river. This condition persisted for several days until repeated icebreaker passage through the jam area, coupled with the action of current eroding the jagged undersurface of the ice cover, caused levels to recede below flood stage. During the initial development of these ice jam situations, the passage of commercial vessels was suspended so as not to further contribute to the problem.

A heavy ice jam that persisted through much of the winter has covered the lower river for three of the seven winters of the Demonstration Program. This has frequently caused ships to become stuck in the ice, requiring icebreaker assistance for getting them moving again.

Generally, dock and shore structure damage occurs during periods of heavy ice jams. Some damage has occurred in the Algonac area and along Harsens Island when large ice floes collect around a structure and freeze together in a large mass. Occasionally, this ice will move under the forces of wind, current, winter navigation, or ice-breaking activities and cause damage to the structure. Many dock owners have placed large wooden pile clusters just off the upstream end of their docks to act as a shock absorber for floe ice. This also helps lock in shore ice in the shallow area shoreward of the pile cluster. Without such protection, small docks have been damaged by normal, current moved ice floes.

In addition to dock and shore structure damage due to ice jams, damage has been reported by dock owners along the St. Clair River resulting from the wakes of passing vessels moving broken ice against and under the structures during periods of significant ice in the river. This causes the structural components to be lifted up, pushed back, or sheared off with resultant property damage occurring.

There have also been isolated cases of shoreline erosion caused by ice piling on shore, generally resulting from the natural effect of wind and current. Much of the shoreline is protected by steel, stone, and wood seawalls. Recent high lake levels have caused extensive erosion along the highway opposite the Algonac State Park. A series of rock-filled gabions have been effective in stabilizing this stretch of shoreline.

Ferry operations across the St. Clair River have not been significantly affected by winter navigation during the Demonstration Program as determined by discussions with each ferry owner, with the possible exception of Harsens Island. There is a general feeling that winter navigation can both help and possibly hinder ferry operations. When the St. Clair River is blocked with ice, the winter traffic up and down the river helps loosen the ice and facilitates ferry movement. There is some concern that continual winter traffic through the ice bridge at Port Huron may cause additional ice floes which could hamper ferry service.

The pilot transfer point at Port Huron, Michigan, is located downstream of the Blue Water Bridge on the American side of the St. Clair River. As this section of the river is relatively free of ice during the winter months, pilot transfer problems should be minimal.

The three power generating plants on the St. Clair River have reported some problems with heavy ice cover blocking cooling water intakes. There is some concern that continual navigation through the ice bridge area at Port Huron could increase the volume of ice floes in the river and possibly add to this type of interference. Utility officials have expressed an interest in being kept continually appraised of season extension plans so that compatibility with the maintenance and operation of generating facilities can be assured. Power plant personnel also noted that increased ice jams could interfere with tug-barge oil deliveries, which currently supplement the use of coal. They believe that winter navigation will benefit

power production by allowing coal to be shipped in throughout the winter.

The effluent from the power plants along the St. Clair River may slightly reduce the ice retardation in that river. However, at this time, no data have been collected on the river to substantiate this hypothesis.

Ports on the St. Clair River, as shown in Figure 9, are primarily located in the upper river at Port Huron, Marysville, and St. Clair, Michigan, and are usually ice-free most of the winter, except for occasional ice floes moving down from Lake Huron. There are no anticipated problems at the docks, but ice jams in the lower St. Clair River are frequent and severe enough to halt shipping. The jams may completely clog the channels and may last for days or possibly weeks.

Lake St. Clair normally remains frozen over much of the winter. Vessel traffic is confined to a 1,000 foot wide navigation channel that is dredged to a 27 foot depth through the length of this shallow lake. Vessels occasionally experience difficulty in transiting this reach when wind shifts the ice cover, either closing the navigation track or shifting it away from the dredged channel. Icebreaker assistance is usually required to re-open the channel.

A large ice arch (bridge) continues to form at the head of the Detroit River one to two miles upstream from Peach Island. During periods of sub-freezing temperatures, the edge of the ice bridge will extend downstream to Peach Island, forming an ice arch on either side of the island. During periods of wind and thaw conditions, the ice bridge will fracture and erode back into Lake St. Clair, causing large ice floes to drift downstream and occasionally jam in the lower river. Vessel traffic appears to cause additional ice to fracture adjacent to the navigation track. It is difficult to assess any

significant increase in ice quantities that entered the river during the Demonstration Program. Winter navigation has prevailed for many years with the almost daily round trip tug-barge fuel deliveries between Sarnia, Ontario, and Detroit-Windsor power plants. There does appear to be a slight increase in ice floes passing downstream related to the increase in vessel traffic.

Two railroad car ferries operate year-round across the upper river between Detroit, Michigan, and Windsor, Ontario. In addition, there are unscheduled operations across the river with tug-barge type vessels carrying oil and salt to various docks up and down the river.

There have been some complaints from ferry operators that ice floes seem to be heavier in recent years. They particularly mentioned the 1976-77 winter when one railroad ferry and one tug-barge operator were not able to operate for several days because of the heavy ice cover and/or floes in the river. This could have resulted from a combination of demonstration vessel transits and the severity of recent winters, particularly 1976-77.

The Detroit River pilot transfer point is located upstream of the Ambassador Bridge on the American side of the river. The pilots are transferred on the mailboat, which is not capable of winter operation. An adequate vessel would be required for year-round total system operation. This problem would occur only if and when ocean going vessels enter the system, as lake vessels do not require pilots.

The lower Detroit River tends to freeze over where the river widens into a series of channels and shallow areas. Winter navigation is restricted to the dredged, diked Livingstone Channel which also allows floe ice to enter Lake Erie. If easterly winds blow Lake Erie ice into the lower end of the Detroit River, ice jams can temporarily plug the Livingstone Channel. The ice jams both hamper navigation and cause water levels to rise upstream.

Icebreaker assistance is usually required to loosen the ice in Livingstone Channel and clear a path into Lake Erie until westerly winds blow the ice back into Lake Erie. Upstream flooding does not appear to be a serious problem. Most shoreline development is designed to tolerate occasional high levels resulting from windblown water backing upstream from Lake Erie during the open water season.

Similarly, shoreline erosion does not appear to be a serious problem. Most shoreline is protected against the current, waves, and changing water levels. Winter navigation is confined to the rock dike Livingstone Channel in the lower river. Most of the upstream shoreline is protected with some form of steel, wood, or rock armor.

Ports on the Detroit River, along the Michigan side, and shown in Figure 9, are located at Detroit, the Rouge River, Ecorse, Wyandotte, and Riverview. There are no significant ice problems at the docking and berthing areas. Occasionally, docks may be surrounded by a thin layer of sheet ice or a layer of loosely packed broken-up floes, but this does not hamper operations.

There are occasional ice jams in the upper and lower river that will temporarily halt or slow down navigation until Coast Guard icebreakers can reopen the channel.

Lake Erie

Lake Erie, being the shallowest of the Great Lakes, is likely to freeze completely over during the winter months. Navigation occurs primarily from the upper lakes into the harbors located along the south shore of the lake. Icebreaking assistance and escort service are considered essential: on the western end of Lake Erie, to maintain a broken ice track to Toledo and Monroe Harbor; to and

through Pelee Passage to keep the main navigation channel ice track open; and on the eastern end of Lake Erie.

Shifting ice conditions are a major problem on Lake Erie, particularly along the south shore harbor entrances and in the western portion of the lake. Because of its shallowness, navigation through the lake, especially on the eastern end, can be very difficult during the spring breakup period when ice turns to a slush condition. This shifting ice has historically created shore erosion problems in the eastern end of the lake. Icebreaking and high-powered vessels can have considerable difficulty moving in these conditions. Preliminary estimates of the necessary icebreaking requirements for this reach have been determined by the U.S. Coast Guard.

There are 12 major harbors in Lake Erie as shown in Figure 10, and described under Base Conditions. Ice problems related to winter navigation are described below.

Monroe Harbor, Michigan, is normally closed to navigation January through March. Major problems anticipated with winter shipping are in maintaining an open vessel track through two feet of stable ice at the harbor entrance and through one foot of ice in the navigation channel and dock areas.

Toledo Harbor, Ohio, has experienced winter navigation for several years with coal shipments being made to power plants along the Detroit River. Although ice thickness up to two feet is experienced in the harbor approach, frequent vessel traffic usually keeps a broken channel through the ice. Occasionally, a Coast Guard icebreaking tug is required to reopen the channel, but winter navigation problems are minimal at this harbor.

Marblehead Harbor, Ohio, is primarily an unsheltered private dock extending out into deep water and is used to ship limestone during the ice-free months. Major problems anticipated during winter navigation are maintaining an open vessel track through up to two feet of stable ice to the dock area. On rare occasions, windrowed ice up to ten feet thick may pile up against the dock. However, this condition is usually temporary, lasting less than five days.

Sandusky Harbor, Ohio, is located in shallow Sandusky Bay and is normally closed to navigation during the winter months. Major problems anticipated during winter navigation operations will be maintaining a vessel track through a maximum of two feet of ice at the harbor entrance. In addition, ice eight to ten inches thick adjacent to the docking areas may hinder docking operations.

Huron Harbor, Ohio, is normally closed to navigation during the winter months, January through March. Major problems anticipated for winter navigation are maintaining a vessel track through the navigation channel and docking area in ice up to 20 inches thick. Also, ice windrows across the harbor entrance may exist for periods up to five days during periods of strong, onshore winds.

Lorain Harbor, Ohio, is normally closed to navigation during the winter months, January through March, although ore carriers have come into Lorain as late as early February in recent years. The major impediment to year-round navigation is the periodic ice jams at the harbor entrance that can at times extend to the channel bottom. This problem is transient, but the frequency, magnitude, and duration depend primarily on the prevailing wind conditions.

Cleveland Harbor, Ohio, is normally closed to navigation, January through March, except during the winter of 1973-74 when ore carriers used the outer harbor until early February. The major impediment to year-round navigation is the periodic ice jams that form at the harbor entrance that can, at times, extend to a depth of

16 feet. Similar to ice problems at Lorain Harbor, the frequency, magnitude, and duration of the jams depend on the prevailing wind conditions. These conditions rarely last more than four days at a time before winds shift and move the ice away from the harbor.

Fairport Harbor is normally closed to navigation during the winter months, primarily because most of the present traffic consists of quarry products which are not available in winter. The major problem to year-round navigation is the periodic ice jams that form at the harbor entrance that can, at times, extend to the channel bottom. These conditions rarely last more then a few days at a time, but frequency, magnitude, and duration depend on the prevailing wind conditions. There is a level ice cover over one foot thick in the navigation channel and docking areas that could present a navigation problem to unescorted ships. Ice skating, boating and fishing activities in the outer harbor may be curtailed in the vicinity of the shipping lanes.

Ashtabula Harbor, Ohio, is normally closed to navigation three to four months each winter. As typical with many harbors along the south shore of Lake Erie, ice jams at the harbor entrance present the major impediment to year-round navigation. These conditions are transient, but frequency, magnitude, and duration depend primarily on prevailing wind conditions.

Conneaut Harbor, Ohio, has experienced year-round navigation and/or late winter shipping in recent years. The major problem that hinders winter navigation is periodic windblown ice jams which form at the harbor entrance. These have, at times, extended to the channel bottom. They rarely last more than a few hours or days, but frequency, magnitude, and duration is dependent on the prevailing wind conditions.

Erie Harbor, Pennsylvania, is located in a well-sheltered bay that develops a stable ice cover two to three feet thick. It is anticipated that the major problem to hinder winter navigation will be maintaining an open vessel track into the harbor, and around the dock areas. In addition, there is an occasional and temporary problem with windrows that form outside of the harbor entrance. There is extensive winter recreational use of Presque Isle Bay, primarily for ice fishing, ice boating, and snowmobiling. Some problems could arise from people straying into the harbor area if it is not sufficiently marked.

Buffalo Harbor, New York, comprised of about 4.5 miles of lakeshore protected by breakwaters, plus sections of the Buffalo River, the Niagara River, and several short ship canals, is normally closed to navigation three to four months each winter. Prevailing southwest winds tend to cause windrowed ice to back up into the lake for several miles, including the north entrance to Buffalo Harbor. Unescorted ship passage through these jams is not possible. Occasionally, even ice breakers have difficulty in moving through this area, which raises the possibility that harbor operations could be curtailed in the latter portion of the winter. The north part of the harbor and the Black Rock Canal is generally covered with level ice up to two feet thick that could hamper navigation, particularily at the docking and berthing areas. Some ice fishing that occurs in the harbor may be restricted by winter navigation.

Niagara River

No commercial navigation is anticipated for the Niagara River during the ice season. During the open water period a limited number of vessels transit through the Black Rock Canal lock (which bypasses the swift current under the Peace Bridge) to visit ports in Tonawanda and Niagara Falls, New York.

Black Rock Canal

This canal and lock is not anticipated to operate during the winter season.

Welland Canal

The Canadian Welland Canal, which provides the deep draft navigation connection between Lake Erie and Lake Ontario, includes a series of eight locks interconnected by deep draft (27 foot) channels. A number of winter navigation improvements are in various stages of consideration and construction at this facility. Icing of lock gates and ice buildup in gate recesses and at the lock approaches are among those problems associated with winter navigation. Problems are very similar to those experienced in the locks at Sault Ste. Marie in the St. Marys River. A heavy ice condition at the Lake Erie entrance to the Welland Canal due to wind-blown ice on Lake Erie is a significant problem hindering winter navigation.

Lake Ontario

Lake Ontario is relatively ice free during most winters with the exception of the eastern one-quarter where the prevailing winds and shallow depths combine to produce and raft significant ice thicknesses. Navigation would occur primarily along the lake between the eastern end of the Welland Canal at Port Weller and the head of the St. Lawrence River at Tibbetts Point. Active Canadian ports are expected to be Hamilton, Port Credit, Toronto, and Oshawa, Ontario.

There are only two commercial harbors along the United States shoreline in Lake Ontario as shown in Figure 12 and described under Base Conditions. Ice problems affecting winter navigation are described below.

Rochester Harbor, New York, is not used in winter. Prior to 1950, a car ferry operated year-round to Cobourg, Ontario. Because of the harbor location, the predominant winds and current keep the outer harbor area ice free most of the winter. The harbor, river, and dock area usually remain open throughout the winter. During a severe winter, the docking areas may experience two to three inches of level ice. The harbor can currently operate year-round with no delays or problems due to ice.

Oswego Harbor, New York, is located about 45 miles south of the head of the St. Lawrence River. The harbor is the terminus of the Oswego Canal, of the New York State Barge Canal System, and consists of an outer harbor enclosed by a breakwater and an inner terminal harbor in the Oswego River. The normal navigation season corresponds to the opening and closing of the Welland Canal and the Seaway. Major commodities shipped at the harbor are fuel oil, cement, and crude petroleum.

St. Lawrence River

With improvements in icebreaking and ice control works, the season in the most easterly Canadian section, from the Gulf of St. Lawrence to the City of Montreal, is open to shipping on a year-round basis. The westerly portion, from Lake Ontario to Montreal Harbor (Figure 13), below St. Lambert Lock, is closed to navigation from about mid-December to early April for two primary reasons. First, ice in the river presents a major obstacle to ship movement and could prevent ship passage. Second, ice jams could impact on power generation at the major Moses-Saunders hydroelectric generating station that exists in this portion of the river. There is concern that ship traffic would disrupt the integrity of stable ice cover in critical reaches of the river. This could lead to reduction in river discharge which can adversely affect the requirements of the International Joint Commission's (IJC's) Lake Ontario regulation

scheme, and consequently reduce power generation at the Moses-Saunders Station and downstream at Beauharnois. Additionally, should reductions of river discharge occur, Lake Ontario levels would rise.

If winter navigation is to be extended, through all or part of the winter in th. upper river, a number of problem areas require solutions.

The seaway capacity is strongly influenced by ship lockage time and the problems caused by ice and winter operation. Lock problems, pertaining to the two U.S. locks (Eisenhower and Snell) and applicable to the five Canadian locks, are grouped in the following five categories:

1. Ice adhering to lock walls prevents ships from entering or makes entrance more difficult.

2. Upper or lower lock gates cannot open fully because of ice accumulation in mitre gate recesses, edges, and contact blocks.

3. Ice pushed into locks by a ship preventing the ship from entering the lock.

4. Failure of lock equipment which requires repair before lock operations continue.

5. Increased maintenance needs with less time available for accomplishing the maintenance.

These problems are similar to those experienced at the Soo Locks.

Currently, the power entities on the St. Lawrence River annually install ice booms spanning various portions of the river to insure a

stable ice cover above the power plants after the last ships leave the system in early winter.

The ice booms between Prescott, Ontario, and Ogdensburg, New York and between Galop Island and the U.S.-Canadian mainland traverse the navigation channel and would impede winter navigation.

There is also concern that winter navigation could disrupt the natural ice cover of the river, particularly in the reach between Galop and Ogden Islands. This area is relatively swift flowing and has a high risk potential for ice jams.

Problems have been encountered under natural conditions with cooling water intakes at the Reynolds Aluminum plant along the St. Lawrence River.

The formation of ice jams might have a significant effect on ship movement in the river. That is, once the jams form, ships can get stuck and cause the subreach in which they form to become the constraining reach in the system. Ice jams form very quickly, and within a matter of a day or two the ice thickness can become so great that ships can not navigate the reach in which they occur. In order to allow navigation to proceed in these critical reaches, various ice control measures are considered necessary.

Structural components of ice booms are primarily floating timber sections connected to each other by heavy steel cable and/or lengths of chain. A problem exists with the present booms since they extend shore to shore and do not allow the passage of ships or withstand the additional forces which might be transmitted to the boom by downbound ships.

Another major impediment to ships transiting the Seaway is the increased growth of ice in the navigation channel in certain sub-reaches. This phenomenon occurs as a result of ships breaking the insulating layer of ice and exposing water to freezing temperatures after each passage. The water near the surface freezes rapidly and adds to the accumulation of ice already in the ship channel. It was found that the ice could accumulate to such proportions that ships would be severely slowed and even halted unless means were provided to remove some of this ice from the ship channel.

Each year, the floating, lighted conventional aids to navigation are removed prior to freeze-up to prevent their being damaged, moved, or sunk by moving ice. As a result, navigation is limited to daylight hours only and the system capacity decreases to about 1/3 of a normal 24-hour day. A need exists for additional permanent aids to navigation to be constructed in shallow water or on shore. There is also a need for floating buoys that remain functional in ice conditions and/or an all-weather electronic navigation system.

Investigation into the shoreline character of the U.S. portion of the St. Lawrence River revealed that approximately 29 miles of that shoreline has the potential to be affected by winter navigation. The areas of high potential are distributed from Clayton to the all-Canadian portion of the river. The remaining shoreline area is fairly evenly distributed between medium potential effect and low potential effect.

Existing soil types, shoreline slope, and the presence or absence of vegetative cover in the reach identified above contribute to varying degrees of erosion now occurring. Future studies, using baseline data already developed will permit evaluation of season extension activities and their effect, if any, on shoreline changes now occurring. The magnitude of shoreline changes, if any, resulting from season extension efforts would be determined by comparison with naturally occurring erosion processes.

It is unlikely, due to the nature of the ownership of the shoreland downstream of Iroquois Dam, that additional erosion will have impacts on large numbers of shore structures. This is based upon the fact that the Power Authority of the State of New York (PASNY) owns the majority of the shoreland from the Moses-Saunders Power Dam upstream to the vicinity of the Ogdensburg bridge. In addition, PASNY's current policy prohibits year-round structures from being placed in the water along the lands that it leases. Few permanent or seasonal residences are near enough to the river to be in danger of erosion impacting them.

The details of the nature and extent of any protection measures required would be determined during the course of future investigations that would identify specific locations, if any, undergoing accelerated shoreline changes as a result of winter navigation.

With the identification of over three hundred shore structures upstream of Iroquois Dam that have the potential to be affected by extension of the navigation season, the development of a program to identify and evaluate alternative methods of reducing or eliminating these impacts appears necessary. Included in this program would be an evaluation of remedial engineering techniques that could be applied to existing structures; determination of the minimum construction standards that would be required of new construction in order that the impacts would be withstood; development of an acceptable liability program to handle any damage that may occur; and development of a program to disseminate this information.

With the consideration for year-round navigation on the entire Great Lakes and St. Lawrence Seaway, there is a potential problem with year-round island residents in the St. Lawrence River who reside, on a year-round basis, on islands where the navigation

channel is between them and the mainland. During the winter season, these residents, who historically have used the solid ice cover as a means of transit between the mainland, may encounter an open water/broken ice filled vessel track which could impede traditional transportation methods. Two islands have been identified as accommodating year-round residents. Both are situated within the Thousand Islands area of the St. Lawrence River, namely: Wellesley and Grindstone Islands (See Figure 13). A winter navigation vessel track would have no effect on the year-round residents of Wellesley Island, because a bridge connects the Island with the mainland. For Grindstone Island, a problem would be created which would require the provision of an alternative means of transportation.

A problem exists at the entrance to the St. Lawrence River at Cape Vincent, New York, where commercial vessels pick up and drop off pilots that assist the ships in navigating the St. Lawrence System. Normally, two small boats ferry the pilots from the dock at Cape Vincent to the passing vessels and back again. The existing boats are totally inadequate for use during full winter ice conditions and cannot transit through heavy sheet ice or ice floes. If this service is to continue into the ice season, an alternate means of transporting the pilots would be required.

With regard to winter recreation along the St. Lawrence River, a study on ice fishing at four sites near navigation channels on the River was conducted during the winter of 1975-76. These sites were Cape Vincent, Wellesley Island, Chippewa Bay, and Coles Creek. The major conclusions of the study were that: (1) the weakening of the ice cover from icebreaking would not affect embayments where most ice fishing takes place; (2) ice fishing was a major form of recreation for a small number of people living nearby; and (3) ice fishing at these sites near the navigational channel did not constitute a major economic stimulant to the area. This last conclusion was tentative in that the winter during which the study was conducted was unseasonably mild.

Vessel traffic control in the St. Lawrence River for prevention of collision, rammings, or groundings is provided by the St. Lawrence Seaway Development Corporation/St. Lawrence Seaway Authority (SLSDC/SLSA) between Montreal and Long Point in Lake Erie. The existing Vessel Traffic Service is only used when the Welland Canal or St. Lawrence River is open to navigation. This Service, which includes vessel movement reporting and closed-circuit television surveillance of selected locks and lock approaches, would be adequate for winter navigation as well.

Associated Problems

The most important legal problems involve determination of liability for adverse impacts on riparian property owners and power interests arising from an extension of winter navigation season on the Great Lakes and St. Lawrence System (see Appendix J - Legal Considerations).

The most important areas for potential damage arising from the extended navigation season are: (a) shoreline structural damage; (b) shoreline erosion; (c) adverse impacts on power generation; and (d) adverse environmental and social impacts.

It should be noted that shore erosion and shore structure damages occur under existing conditions from natural ice, wave, and wind forces. Extension of the navigation season to 31 January may contribute to those damages. Structural damage that occurs below the ordinary high watermark is subject -- unless changed by law -- to navigational servitude. Thus, the Federal Government would not be liable for damages below the ordinary high watermark, if any, caused by winter navigation. The ordinary high watermark on the Great Lakes

is generally defined as four feet above the published low water datum on all of the Great Lakes, except that it is two feet above on Lake Superior and the Upper St. Marys River. Studies have been completed under the survey investigation of season extension to identify any such damages and develop plans for protection measures.

Currently, riparian interests cannot recover for damage to their property caused by vessels engaged in navigation unless there is a showing of willful misconduct or negligence. There is no known authority suggesting that damage caused by navigation during winter is to be treated any differently than damage caused by navigation in general. Therefore, although riparian interests might suffer increased shoreline erosion and shore structure damage as a result of the extension of the winter navigation season, the existing legal remedies for such damage are limited and are described in Appendix J-Legal Considerations.

Another immediate problem associated with an extension of the winter navigation season in the International Section of the St. Lawrence River involves concern for the potential liabilities and rights of the power entities. Although such concern extends to Ontario-Hydro of Canada (and to a lesser degree to Quebec-Hydro), this specifically addresses the problems posed by the Power Authority of the State of New York (PASNY).

PASNY contends there may be possible losses in power generating ability from interference with the normal ice cover by winter navigation. Based on the commerce clause of the United States Constitution, Congress has a paramount right to regulate commerce and promote navigation. A problem that concerns PASNY is its obligation under the 1952 Order of Approval to give suitable protection and

indemnity to all interests injured by operation of the power works, which include the existing ice booms. In the face of a program authorized by Congress pursuant to its power to regulate commerce, PASNY stated it has legal remedies for losses incident to improvements for navigation, under terms of its Federal Power Commission license and the International Joint Commission Order of Approval which was approved by the governments of Canada and the United States.

A stable ice cover has been essential to maintain adequate flows to discharge water for the regulation of the level of Lake Ontario pursuant to the 1952 Order of Approval of the International Joint Commission, as well as for power generation in the St. Lawrence River. This stability has been attained to date by the use of ice booms across the entire width of the river, which are installed and operated by the power entities. As now constructed and operated, these ice booms prevent winter navigation in the International Section of the river.

A unique concern is one that directs attention to localized weather problems brought about by the installation of ice control structures. It has been suggested that areas of open water previously covered by ice could cause fog or cause other weather disturbances. It is also possible that a more fractured ice cover could increase the danger of gale force winds dislodging large sheets of ice, causing damage to anchored or transiting ships, and to shorelines. These are problems which should be considered in each area where new control structures are contemplated.

Another problem that should be considered for ocean vessels entering the system is providing pilots that are familiar with the Great Lakes-St. Lawrence River system under both ice and open water conditions.

The survey and dredging of shoaling in channels and harbors during the winter season -- should it have to be done -- will present additional problems. For instance, harbor entrances on the eastern shores of Lake Michigan have experienced shoaling during the winter months due to winter storm wave activity. Automated survey equipment would have to be installed on larger or modified vessels capable of working in heavy ice. Distance measuring equipment would require heated or insulated shelters. Disposal of dredged material would become difficult if allowed to freeze into a solid mass. Pumping dredged material into confined disposal areas through long pipelines would be difficult in extremely cold temperatures. Survey crews would require special training, clothes, and safety equipment to operate safely and effectively under exposure to severe winter weather.

The Treaty of 1909 between Canada and the United States created the International Joint Commission (IJC) with jurisdiction over all matters related to the use or obstruction or diversion of waters of the Great Lakes which would affect the use of these boundary waters by the other nation. This extended navigation season survey study has identified some potential impacts. Thus, it appears it would be necessary to either obtain IJC approval to fully implement an extended navigation program or, alternatively, obtain a separate agreement between the two countries.

In dealing with environmental concerns, it was recognized during the early stages of studying the feasibility of extended winter navigation that it would not be possible to prepare an Environmental Impact Statement for the Survey Report that would identify all specific impacts because of the insufficient environmental data and detailed engineering design information. To resolve this problem, predictive environmental assessment would be prepared and baseline and monitoring studies conducted during advanced engineering and design and construction activities.

There is an extensive data base on certain portions of the Great Lakes environments, but meager information exists on ecological conditions during winter or on the expected impacts of the Extended Season Program. Substantive environmental data have not been gathered on similar navigation programs in the United States or other countries. Implementation of the Environmental Plan of Action (EPOA) would provide the necessary information.

The EPOA is the primary tool of the Adaptive Method which would minimize, mitigate or eliminate environmental damage from extending the winter navigation season on the Great Lakes System and, where possible, enhance environmental quality.

The studies contained within the EPOA are grouped into two types: site-specific and system-wide. Site-specific studies would investigate those impacts that influence a harbor or river. On the other hand, system-wide studies address more far-reaching effects on a lake, Connecting Channel, or the entire Great Lakes system. Because of the amount of data necessary to defect cumulative effects, these studies would be more complex and would require more time than site-specific studies.

Detailed environmental impact assessments would be made during the early stages of preparing the Phase I General Design Memorandum (GDM). Detailed Environmental Impact Statements (EIS), incorporating the assessments information, would be prepared to accompany each Phase I GDM.

This means that extensive information must be available to prepare an adequate impact assessment early in Phase I. Additional assessments would be made throughout all stages of preparing the Phase I and II GDM's. Should the assessments indicate a need, additional Environmental Impact Statements would be prepared to

accompany the Phase II GDM. During the construction and operational periods, data would be collected to monitor effects. Finally, the total effect would be evaluated and a validation report written. If unacceptable environmental impacts are identified before final impact evaluation, modifications would be implemented and the impact assessment procedure modified accordingly. It may require 10-15 years from initial planning of an activity to final evaluation.

PUBLIC INPUTS

The expressed views, desires, and concerns of the public; including Federal, state, and local governments, are included in the Public Views and Responses on the Report and Environmental Impact Statement Appendix of this report (Appendix C). Specifically, the inputs received at public workshops and meetings are summarized in digests of the workshops and meetings. Copies of statements by Governors and State Officials at the public workshops and meetings are also included with the digests. Copies of letters received from the public and Federal, state, and local governments on both the Survey Study and Demonstration Program are also included as a part of Appendix C.

PROBLEM SUMMARY

The information which follows in Table 7 identifies, in tabular form, the engineering problems and needs associated with the proposed extension of the navigation season, as discussed in this Appendix. Appendix B, Plan Formulation, details alternative solutions to these problems and recommends preferred courses of action for improving operations in the navigation system.

Social impacts possibly resulting from navigation season extension are discussed in Appendix H, while environmental impacts are treated in detail within Appendix F and in the Environmental Impact Statement.

TABLE 7

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified
A. Lake Superior		
I. Open Lake	a.	Vessel movement through ice rafting and windrows
	b.	Ice and weather information operations for shippers
	c.	Aids to navigation
	d.	Vessel-crew safety/survival and search and rescue
	e.	Prevent spills of oil and other hazardous substances
	f.	Water quality
II. Harbors	a.	Vessel movement through shifting ice at entrances
	b.	Ice conditions within harbors
	c.	Lack of all-weather aids to navigation
	d.	Mooring facilities for icebreakers
III. Whitefish Bay	a.	Vessel movement thru shifting ice conditions
	b.	Ice and Weather Information for Shippers
	c.	Lack of all-weather aids to navigation
B. St. Marys River		
I. St. Marys Falls Canal (Soo Locks)	a.	Removing ice collar on lock walls

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified	
I.	St. Marys Falls Canal (Soo Locks) (Cont.)	b.	Removing ice out of lock
		c.	Ice in gate recesses
		d.	Wear and tear on lock mechanical & structural equipment
		e.	Wear and tear on floating plant
		f.	Revision of maintenance program
		g.	Safety boom operation
		h.	Abrasion on walls and culverts
		i.	Bottom scouring in west approach channel
		j.	Removing ice from upstream lock entrance
		k.	Removing ice from downstream lock entrance
		l.	Ice formation on lock gates
		m.	Lock wall fender damage
		n.	Passage of 105' x 1000' vessels
II.	Island Access Transportation	a.	Sugar Island
		b.	Neebish Island
		c.	Lime Island
		d.	Drummond Island

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified
III. Potential Ice Jams & Flooding	a.	Little Rapids Cut
	b.	West Neebish Channel
IV. Vessel Movement	a.	Tight Turns: Whitefish Bay (Birch Point Turn) Middle Neebish Channel Angle Course 5 & 6 Angle Course 6 & 7 Angle Course 7 & 8 Angle Course 8 & 9 Lime Island Turn
	b.	Balance of St. Marys River System
V. Shoreline Areas near Navigation Channels	a.	Shoreline Erosion
	b.	Dock Damage
VI. Pilot Access		DeTour
VII. Power Generation	a.	Frazil ice entering Soo Edison Power Plant
	b.	Potential flood damage to Edison Sault power facility
VIII. Other St. Marys River Problems in General	a.	Lack of all-weather aids to navigation
	b.	Oil Spills
C. Lake Michigan		
I. Open Lake	a.	Vessel Movement through ice rafting and windrows
	b.	Ice and weather information for shippers

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area	Specific Problem Identified
I. Open Lake (Cont.)	c. Aids to navigation
	d. Vessel-crew safety/survival and search and rescue
	e. Prevent spills of oil and other hazardous substances
	f. Water quality
II. Harbors	a. Vessel movement thru shifting ice at entrance
	b. Ice conditions within harbors
	c. Lack of all-weather aids to navigation
	d. Mooring facilities for icebreakers
III. Green Bay and Grand Traverse Bay	a. Vessel movement through ice rafting and windrows
	b. Ice & weather information for shippers
	c. Lack of all-weather aids to navigation
D. Lake Huron	
I. Open Lake	a. Vessel movement through ice rafting and windrows
	b. Ice & weather information for shippers
	c. Aids to navigation
	d. Vessel-crew safety/survival and search and rescue

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified
I. Open Lake (Cont.)	e.	Prevent spills of oil and other hazardous substances
	f.	Water quality
II. Harbors	a.	Vessel movement through shifting ice at entrance
	b.	Ice conditions within harbors
	c.	Lack of all-weather aids to navigation
	d.	Mooring facilities for icebreakers
III. Saginaw Bay	a.	Vessel movement through ice rafting and windrows
	b.	Lack of all-weather aids to navigation
E. St. Clair-Detroit River System		
I. Potential Ice Jams and Flooding		Broken Lake Huron ice filling St. Clair River
II. Shorelines		Shore erosion and dock damage
III. Ferry Crossings		Harsens Island, Algonac/ Walpole Is. Roberts Landing/Port Lambton, Marine City/Sombra
IV. Pilot Access		Detroit

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified
V. Other Problems in General	a.	Lack of all-weather aids to navigation
	b.	Oil Spills
	c.	Maintain natural ice retardation effects
F. Lake Erie		
I. Open Lake	a.	Vessel movement through ice rafting and windrows
	b.	Ice and weather information for shippers
	c.	Aids to navigation
	d.	Vessel-crew safety/survival and search and rescue
	e.	Prevent spills of oil and other hazardous substances
	f.	Water quality
II. Harbors	a.	Vessel movement through shifting ice at entrances
	b.	Ice conditions within harbors
	c.	Lack of all-weather aids to navigation
	d.	Mooring facilities for icebreakers
III. Pelee Passage		Vessel movement through shifting ice conditions

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified
IV. Buffalo Harbor & Entrance to Welland Canal		Vessel movement through shifting ice, windrowing and rafting ice
G. Welland Canal		
I. U.S.- Canadian Coordination		Provision of improvement necessary for year-round navigation
II. Winter Operations	a.	Removing ice collar on lock walls
	b.	Removing ice out of lock
	c.	Ice in gate recesses
	d.	Wear and tear on lock mechanical & structural equipment
	e.	Wear and tear on floating plant
	f.	Revision of maintenance program
	g.	Safety boom operation
	h.	Abrasion on walls and culverts
	i.	Bottom scouring in west approach channel
	j.	Removing ice from upstream lock entrance
	k.	Removing ice from downstream lock entrance
	l.	Ice formation on lock gates
	m.	Lock wall fender damage

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area	Specific Problem Identified
H. Lake Ontario	
I. Open Waters	a. Vessel movement through ice rafting and windrows
	b. Ice and weather information for shippers
	c. Aids to navigation
	d. Vessel-crew safety/survival and search and rescue
	e. Prevent spills of oil and other hazardous substances
	f. Water quality
II. Harbors	a. Vessel movement through shifting ice at entrance
	b. Ice conditions within harbors
	c. Lack of all-weather aids to navigation
	d. Mooring facilities for icebreakers
I. St. Lawrence River	
I. St. Lawrence River U.S. Navigation Locks (Eisenhower & Snell)	Provide winter operation capabilities
	a. Ice removal from mitre gates and operating equipment
	b. Unobstructed operation of mitre gates
	c. Prevent lock wall icing

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified
I. St. Lawrence River U.S. Navigation Locks (Eisenhower & Snell) (Cont.)	d.	Prevent floating ice from entering locks
	e.	Removal of floating ice from locks
II. St. Lawrence River/ Canadian Locks (St. Lambert, St. Catherine, Beauharnois, Melocheville, Iroquois)		Provide winter operation capabilities
	a.	Ice removal from mitre gates and operating equipment
	b.	Unobstructed operation of mitre gates
	c.	Prevent lock wall icing
	d.	Prevent floating ice from entering locks
	e.	Removal of floating ice from locks
III. Maintain* stable ice cover & prescribed levels and flows in critical channel reaches. Transiting ice booms.	a.	Ogdensburg-Prescott Area
	b.	Galop Island Area
	c.	Ogden Island Area
	d.	St. Regis Island
	e.	Beauharnois Canal
IV. Other St. Lawrence River Problems in General	a.	Lack of all-weather aids to navigation
	b.	Icebreaking
	c.	Channel Clearing

*Canadian co-participation required

TABLE 7 (Cont.)

ENGINEERING PROBLEMS

General Problem Area		Specific Problem Identified	
IV.	Other St. Lawrence River Problems in General (Cont.)	d.	Provide ice and weather information to shippers
		e.	Shore erosion and structure damage
V.	Island access transportation		Thousand Islands area-Grindstone Island
VI.	Pilot Access		Cape Vincent

Information presented in Appendix A has provided a description of the base condition of the Great Lakes and St. Lawrence Seaway navigation system, and identified problems associated with navigation season extension on the system. In Appendix B, Plan Formulation, recommended solutions to these problems are spelled out and cost tables presented. Social and environmental impacts which may result from the implementation of a navigation season extension program are detailed in Appendixes H and F, and the Environmental Impact Statement.

APPENDIX B

FORMULATION OF
DETAILED PLANS

AUGUST 1979

APPENDIX B

FORMULATION OF DETAILED PLANS

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APPENDIX B
FORMULATION OF DETAILED PLANS

INTRODUCTION

The Great Lakes and St. Lawrence Seaway Navigation Season Extension Study, as authorized by Congress in its three distinct sections, is explicitly limited in scope of investigation to matters (specifically defined as) related to winter navigation. The scope of study includes investigating the feasibility of means of extending the navigation season on the entire system, into the winter months, beyond the usual 8-1/2 month season to as much as year-round; and to determine the desirability and extent of federal participation. The authorizing language leaves no latitude for investigation of other system improvements to increase the capacity or the productivity of the Great Lakes and St. Lawrence Seaway Navigation System. Congressional direction and funding subsequent to the authorization provided further continuing guidance as to the specific nature of this investigation. The eight-year Demonstration Program, which forms the primary data base for means and methods of controlling and managing ice and for determination of practicability of vessel operations in ice, has been carried out under this directed scope. This feasibility report is similarly directed. It should be noted at the outset that relevant system matters such as lock capacity, channel dimensions, impacts on levels and flows, and other navigational matters and features will be explored as to their relevance to winter navigation. However, none of these is a purpose of the investigation as defined in the scope. Further, the scope of this study involves U.S. harbors, shorelines, the five Great Lakes and connecting channels, and the international section of the St. Lawrence River. The study includes known Canadian plans for winter navigation projects or programs that would affect U.S. proposals. It is not within the scope of this study to include a Canadian plan of improvement to determine Canadian feasibility of winter navigation, nor to estimate Canadian benefits or Canadian costs. This is a matter for the Canadian Government, it will be entirely a Canadian prerogative.

Formulating a plan for the extension of the navigation season is a single purpose planning process which develops and evaluates the feasibility of alternative plans for extending the navigation season on the Great Lakes/St. Lawrence Seaway. Alternatives to the study are screened out and a number of feasible plans are designated for further consideration. A number of other potential modifications to the navigation system are under long-range consideration under investigation authorities separate from the authority for the extended navigation season investigation. These include need for a new large lock at the St. Marys Falls Canal in Michigan, need for additional locks in the St. Lawrence Seaway, and channel and harbor modifications including potential deepening of the Great Lakes system. Such considerations are separate and distinct from the consideration of season extension. They are not alternatives to season extension. The formulation process for selecting viable alternatives recognizes, fully, that an increase in prospective traffic is constrained by the existing system. Most season extension plans are separable modifications to the system, wholly independent in both costs and benefits.

Analysis indicates that season extension should proceed first as the least net intensive relative to the other possible modifications as discussed above. While the primary intent of the investigation is not to provide additional system capacity, the effect of each season extension development plan is to increase capacity as well as productivity of the existing system.

PLANNING CONSTRAINTS

Planning constraints are based upon identified area resource management problems and specify limitations to direct plan formulation and restrict impacts. The constraints used in the formulation analysis are as follows:

a. Avoid or minimize damage to shorelines, structures and wetlands from vessel induced increased ice pressure or ice movement.

b. Avoid adverse effects to power plants by promoting a stable ice cover and the required river discharge.

c. Avoid adverse effects to low-lying communities from project-induced hanging dam and ice-jam flooding.

d. Avoid adverse impact to the overall water quality of the Great Lakes.

e. Avoid irreversible commitments of the environment prior to determining the ramifications of the proposed actions.

PLANNING OBJECTIVES

A sec of planning objectives was formulated based upon the water and related resource management problems, needs and opportunities identified for the Great Lakes and St. Lawrence Seaway region. In addition to addressing the region's problems, the objectives listed below contribute to the national goals of national economic development (NED) and environmental quality (EQ). The following planning objectives served as general guidelines for the plan formulation process:

a. Promote efficient utilization of the navigation intrastructure of the Great Lakes/St. Lawrence Seaway system;

b. Contribute to an increase in output of goods, services and external economics of the Great Lakes/St. Lawrence Seaway system;

c. Contribute to the maintenance of the required water levels of the Great Lakes and discharge of the St. Lawrence River;

d. Maintain Great Lakes island settlements as viable social communities; and

e. Contribute to the quality of the Great Lakes/St. Lawrence Seaway environment, giving particular attention to the winter ecosystem and water quality of the lakes.

FORMULATION AND EVALUATION CRITERIA

The formulation and evaluation of alternatives is done considering technical, economical, environmental, social, and institutional criteria to allow the development, comparison, and selection of plans that best respond to the problems and needs.

Technical Criteria Used Are:

a. Improvements should be adequate to accommodate expected user vessels for the economic life of the project which is amortized over a 50-year period;

b. Improvements should provide for optimum utilization of existing facilities;

c. Alternatives should allow for safe, efficient movement of expected user vessels;

d. Improvements should be sound, practicable, engineeringly feasible, and environmentally acceptable;

e. Technical solutions with the least adverse environmental impacts should be used; and,

f. If necessary, corrective and/or mitigative measures should be made part of the engineering solutions.

Economic Criteria Used Are:

a. Project dollar benefits should exceed project dollar costs;

b. Separable units of improvement should provide dollar benefits at least equal to its dollar cost;

c. The scope of the development should be such as to provide --certainly identify--the maximum net benefits;

d. Annual costs including operation and maintenance should be based upon a 50-year economic life and an interest rate of 7-1/8 percent;

e. There should be no more economically or environmentally acceptable means of accomplishing the same purpose or purposes that would be precluded from development if the plan were undertaken; and,

f. Projected project disbenefits, and environmental and social costs must be included and if possible, quantified.

Environmental Criteria Used Are:

a. Provide for management, protection, or enhancement of ecological systems;

b. Provide for management, preservation, or enhancement of specially valuable or outstanding archaeological, historical, biological, or geological resources;

c. Provide for enhancement of quality aspects of water, land, and air by control of pollution or prevention of erosion and restoration of already eroded areas caused by winter navigation;

d. Provide for management, protection, or enhancement of aesthetic areas; and,

e. Provide for avoidance of unnecessary irreversible commitment of resources to future use.

Social Criteria Use Are:

a. Avoid unnecessary and/or unreasonable risk of loss of life and hazard to health and safety;

b. Preserve or enhance social, cultural, educational, and historical values;

c. Avoid disruption of man-made or natural resources, aesthetic values, community cohesion, and public facilities and services;

d. Consider human environmental benefits and costs equal in status to monetary units;

e. Identify possible employment effects and changes to tax and property values;

f. Coordinate alternatives with local, regional and state interests; and,

g. Evaluate public acceptance of proposed modifications and ability and willingness to meet local requirements.

Institutional Criteria Used Are:

a. Institutional requirements imposed by alternative plans must be an integral part of the project plan formulation process;

b. Coordination should be carried out with existing Federal, state, and local institutions that are operating in or have an interest in the study area;

c. Areas of responsibility of Federal, state, and local institutions should be defined; and,

d. Improvements proposed should be institutionally implementable.

PLAN DEVELOPMENT

Congress has requested that the Corps of Engineers investigate the feasibility of ways and means of extending the navigation season on the Great Lakes-St. Lawrence Seaway System and to determine the degree of Federal participation, if any. The first step in the planning process is problem identification, where information is obtained from the public and agencies about the needs (opportunities and problems) which the study could address. From these needs are derived a set of planning objectives for the study. To help insure that the best overall plan is developed, a range of alternative plans are developed to address the planning objectives and then evaluated. As part of the plan development process, a plan to optimize National Economic Development (NED) and maximize net economic benefits, and at least one plan to maximize Environmental Quality (EQ) contributions, need to be developed.

In March 1976 an Interim Feasibility Report was prepared-House Document No. 96-181. Three alternative plans were developed, analyzed, and evaluated addressing the feasibility of extended season navigation on the

entire Great Lakes-St. Lawrence Seaway System. These were Traditional Navigation Season, Fixed Navigation Season, and Extended Navigation Season. This analysis is presented in Attachment 1 to this Appendix. Based on the analysis and evaluation of the three alternative plans, the Selected Plan in the 1976 Interim Report is Extended Navigation Season and is also designated as the National Economic Development (NED) plan. For the Interim Feasibility Report a fixed Navigation Season was designated as the Environmental Quality (EQ) plan.

Under the Selected Plan, three alternative proposals for extending the navigation season beyond 15 December on the entire system were developed and analyzed - extension to 31 January, 28 February, and 31 March (year-round). Based on economic, environmental, social and engineering information and data as of March 1976 and actual experience (i.e., commercial vessel movement) during the five years of the Demonstration Program between 1971 and 1976, extension of the navigation season on only the upper four Great Lakes to 31 January (± 2 weeks) using basically existing operational measures, with little or no new construction, was recommended in the Interim Feasibility Report. This report was transmitted to Congress on 3 August 1979.

Since 1976, additional economic, environmental, social and engineering data collection and analysis have been conducted to further evaluate the viability and continued progressive development of the Selected Plan. These are discussed in the following paragraphs. In addition, results of the engineering studies showing problems and corresponding solutions together with summaries of other on-going and prior studies related to this survey report are displayed in Attachment 2 to this Appendix.

As part of further plan development of the Selected Plan, six proposals (or schemes for further consideration) have been developed (see Table B-1)

in addition to the Base Condition Plan addressing extending the navigation season, on both a geographic and time extension basis, to 12 months on the upper four Great Lakes and 11-month navigation on the Welland Canal-Lake Ontario-St. Lawrence River International portion of the system. Year-round navigation on the upper four Great Lakes is made possible by having at least two locks (Poe and MacArthur Locks) available for operation at Sault Ste. Marie. Maintenance at the locks would be phased to enable continuous operation of vessels through the lock facilities. The important point is that when the Poe Lock is down for maintenance --currently scheduled for every 5 years--the 105 foot beam vessels would not be able to transit the lock facilities; however, operation of the 767 foot by 76 foot vessels could continue. A phased maintenance program would be designed to minimize the down time of the Poe Lock.

On the St. Lawrence Seaway portion of the system, up to an 11-month navigation season is maximum considered possible at this time. There are adjacent locks at only three of the fifteen lock facilities on the Welland Canal and St. Lawrence River; therefore, at this time, at least one month of down time for maintenance is contemplated to be done during the winter months. The St. Lawrence Seaway Development Corporation of the United States and the St. Lawrence Seaway Authority of Canada are currently investigating the possibilities of phasing their lock maintenance programs on the Welland Canal and the St. Lawrence River over the entire year, rather than performing maintenance all at once during the winter, which is the current mode of operation. If the U.S. and Canadian Governments are able to develop such a lock maintenance program, year-round season extension on the entire Great Lakes-St. Lawrence Seaway System could be feasible without lock twinning. However, for purposes of this analysis, it is assumed that season extension beyond 11 months on the St. Lawrence River would definitely require twinning of the Welland and St. Lawrence River Locks to permit lock maintenance. Therefore, year-round season extension is currently limited to the upper four Great Lakes only. Phasing of the lock maintenance program at the Soo Locks at Sault Ste. Marie, Michigan, to

TABLE B-1

SEASON EXTENSION PROPOSALS 1/

Extended Season Proposals	Estimated Starting Date of Vessel Operations	Lake Superior St. Marys River Lake Michigan Straits of Mackinac Lake Huron	St. Clair River Lake St. Clair Detroit River Lake Erie	Welland Canal Lake Ontario St. Lawrence River
Base Condition	Prior to 1987	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1	1987	Year-round	1 Apr - 31 Jan	1 Apr - 15 Dec
2	1990	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3	1990	Year-round	Year-round	1 Apr - 31 Dec
4	1992	Year-round	Year-round	20 Mar - 31 Dec
5	1995	Year-round	Year-round	7 Mar - 7 Jan
6	2000	Year-round	Year-round	7 Feb - 7 Jan

NOTE: The Chief of Engineers' recommendation on the March 1976 Interim Feasibility Report recommends an extended season program on the upper four Great Lakes to 31 January (± 2 weeks). This is the Base Condition shown above.

1/ The word "proposal" identifies sub-divisions of an overall plan. These proposals have not been developed as exclusive alternatives.

permit year-round navigation on the upper four Great Lakes is considered feasible to make year-round operation possible.

In addition to the development of the six proposals (schemes or possibilities), further consideration is given to the definition of the National Economic Development (NED) plan and the Environmental Quality (EQ) plan, consistent with the U.S. Army Corps of Engineers Policies and Procedures.

NED Plan

The NED Plan addresses the planning objectives of the study in a way to maximize net economic benefits. This plan consists of both non-structural and structural improvements to permit a permanent extension of the navigation season to 12 months on the upper four Great Lakes and up to 11 months on the U.S. portion of the Welland Canal-Lake Ontario-St. Lawrence River reach of the system. Since 1976, additional analysis has been given to improvements to enhance the efficiency of operation of a permanent system-wide extended navigation season program, and the net economic benefits that could be realized, are maximized with this plan as compared to the other alternatives. It is important to note that this plan provides for compensation and mitigation, such as island transportation assistance and shoreline protection, for those environmental/social impacts which have been positively identified from actual operations, during the Demonstration Program and further detailed analyses accomplished since the 1976 Interim Feasibility Report.

EQ (Oriented) Plan

The Environmental Quality (EQ) Plan is that alternative which addresses the planning objectives in such a manner as to make net positive benefits to the EQ account. This requires analyzing the overall environmental contributions of each alternative in comparison with the most probable

future conditions without a project. If it is impossible to designate an EQ (Oriented) Plan that meets these requirements, the alternative least damaging to the environment will be identified.

The EQ Plan for the Great Lakes and St. Lawrence Seaway navigation season extension consists of four basic components: (1) a permanent extension of the navigation season up to 12 months on the upper four Great Lakes, instituted through a phased implementation procedure; (2) an extension up to 11 months on Lake Ontario and the International Section of the St. Lawrence River instituted through a phased implementation procedure; (3) the accomplishment of a system inventory and evaluation of the environmental impacts induced by extended season navigation; and (4) monitoring of certain environmental parameters during winter operation.

The extension of the navigation season for the two geographic components would be physically promoted by both structural (icebreakers, bubblers) and non-structural (vessel speed control) measures. The bulk of the justification of the EQ (Oriented) Plan lies in the environmental considerations commensurate with navigation measures and the benefits yielded: (1) phasing implementation over time and space to allow environmental investigations and prevent irreversible commitment of the environment prior to ascertaining ramifications; (2) increasing the environmental knowledge by means of a system inventory; (3) assessing impacts from a more comprehensive environmental base; (4) monitoring environmental parameters during winter operation; (5) promoting better management of the ecosystem by increasing knowledge of it; and (6) modifying the operation of the project in response to an adverse impact.

This plan provides for an "ADAPTIVE METHOD" for determining the environmental feasibility and taking action to address potential impacts of an extended navigation season program, to be accomplished concurrently with the continued planning, design, and implementation of an authorized program. The approach consists of implementing an Environmental Plan of

Action for environmental base condition data collection, evaluation and assessment, monitoring, and validation--including environmental compensation, mitigation and possibly enhancement--to be done concurrently with the continued planning, advanced engineering and design, construction, and operation phases of the program to ensure environmental compatibility.

The plan of action, to be implemented in conjunction with each major segment of the project during the first 10 to 15 years of the project, would be designed to provide assurance that winter navigation would be conducted in an environmentally acceptable manner, with provisions made for accomplishing any necessary corrective or mitigative actions, including the halting or limiting of vessel traffic if necessary.

These benefits to the environment are measured against those that would occur in the most probable future condition - extension of navigation to 31 January ($\pm$ 2 weeks) by economic pressure and few overt federal actions. Under such circumstances, the potential for some dramatic adverse impacts would exist (accidental spills and possible shore erosion), but would not have the benefits of inventory monitoring or management.

System of Accounts

The System of Accounts is presented to display the significant beneficial and adverse impacts of the alternate plans of action for the purpose of trade-off analysis and decision-making. In addition, the System of Accounts displays the information presently available as a basis to determine what is still to be accomplished.

TABLE B-2
SYSTEM OF ACCOUNTS

PLAN DESCRIPTIONS	NO ACTION PLAN** "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
+See Index on Footnotes on Page B-38 *Asterisk indicates *Section 112 effects*	This is a non-structural plan and involves no planned season extension. Commercial bulk carrier movement limited to the upper four Great Lakes from 1 April to 31 January ± 2 weeks, depending upon weather conditions and reasonable demands of commerce. The St. Lawrence River and Welland Canal would be closed to navigation from approximately 15 December to 1 April, as negotiated on an annual basis by the Seaway operating entities and power authorities on the lower part of the System. **This plan assumes navigation to 31 January ± 2 weeks, as "Base Condition," as stated in the March 1976 Interim Report, submitted to Congress on 3 August 1979 - House Document No. 96-181.	N/A	This plan consists of both non-structural and structural improvements to permit a permanent extension of the navigation season to 12 months on the upper four Great Lakes, and up to 11 months on the U.S. portion of Lake Erie - Lake Ontario - St. Lawrence River reach of the System. The NED Plan maximizes net economic benefits. This plan provides for compensation and mitigation, such as island transportation assistance and shoreline protection, for those environmental/social impacts which have been identified from actual operations.	N/A	This plan would consists of both non-structural and structural improvements to permit a permanent extension of the navigation season to 12 months on the upper four Great Lakes and up to 11 months on the U.S. portion of Lake Erie - Lake Ontario - St. Lawrence River reach of the System. A completely definitive EQ (Environmental Quality) Plan cannot be developed at this time due to a lack of baseline data and monitoring information. An Environmental Quality Oriented Plan addresses planning objectives in such a manner as to emphasize maintenance and enhancement of environmental quality. An EQ Oriented Plan attempts to accomplish the necessary elevation of environmental impacts of an extended navigation season. Through the Adaptive Method, the program would be conducted in an environmentally acceptable manner, and as such, this plan is the least environmentally damaging.	N/A

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

PLAN DESCRIPTIONS	NO ACTION PLAN** "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
+See Index of Footnotes on Page B-38 *Asterisk indicates Section 122 effects.		N/A		N/A	The intent of the EQ Oriented Plan is to provide for accomplishing EQ objectives as opportunities are identified through the EPOA (Environmental Plan of Action), part of the Adaptive Method. These opportunities may arise at any time, from environmental base condition data collection stage through the construction and operation stage. If impacts are found to be unacceptable, the cause would be altered to an acceptable level or eliminated under the EQ Oriented Plan, even to the point of halting vessel traffic. If impacts develop which are considered acceptable but undesirable, appropriate measures would be taken to mitigate, compensate or eliminate the impact.	N/A

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
1. ACCOUNTS: NED a. Beneficial Impacts						
Annual Transportation Savings	None		$175,022,000	2,6,9		2,6 9
Annual Stockpiling Savings	None		$ 23,239,000	2,6,9		2,6,9
Annual Winter Rate Savings	None		$ 7,405,000	2,6,9		2,6 9
Energy	No Savings No Estimate		A small, but positive energy impact is associated with the increased GL/SLS waterborne movement that would result from an extended navigation season. For BTU figures, See Appendix D.	2,5,9	Same as NED Plan.	2,5 9
Source of Savings	N/A		Water transportation: a less costly alternaive relative to overland rates. More efficient utilization of existing Great Lakes fleet; greater annual return on invested capital. Reduction in stockpile inventory and reduction of stockpiling handling costs.			

See Index of Footnotes on Page B-38
Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
NED: Beneficial Impacts						
<u>Impact Parameters</u> (1) Value of increased outputs of goods and services.	None		An interest rate of 7-1/8% was used. The value of services provided by the water transportation industry would increase due to a reliable extended shipping period for shippers. In turn, the value of services and the resulting goods produced would increase in value.	2,6, 9	Same as NED Plan with the additional benefit that EQ Oriented Plan would provide information that could reduce environmental impacts throughout the navigation season, year-round.	2,5 9
(2) Value of output resulting from external economies.	None		Initial benefits caused by the project represent injections into the local port economies caused by an external activity (waterborne cargo traffic). The value of the output caused by this external economy will increase many times through the responding (multiplier effect) of the initial benefits injected into the local economies, also cause for an increase in employment.	2,6 9	Same as NED Plan.	2,6 9
See Index of Footnotes on Page B-38 Asterisk indicates Section 122 effects.						

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
NED: Beneficial Impacts		+		+		+
(3) Value of output from use of unemployed or underemployed resources in construction or installation.	None		The value output of unemployed or underemployed resources will be increased temporarily during construction and to a lesser extent, permanently, because of annual installation and operations of project features.	2,6 9	Same as NED Plan with additional temporary benefit during construction and the early years of operation because of the implementation of the EPOA monitoring effort.	2,5 9
TOTAL NED BENEFITS	N/A			2,6 9	Same as NED Plan minus cost of Adaptive Method.	2,5 9
NED b. Adverse Impacts						
Annual Interest and Amortization	None		$33,194,000	2,6 9		2,5 9
Annual Operations and Maintenance	None		$18,867,000	2,6 9		2,5 9
Annual Disbenefits of Shore Erosion	None		Based on the cost to protect or compensate for the damages of disbenefit amounts.	1,5 9	Same as NED Plan. The implementation of Adaptive Method may reduce or increase this value somewhat as additional information is obtained.	1,5 9
Annual Environmental Disbenefits	No Estimate		No Estimate	3,5 9	Estimates will be developed as a part of the Adaptive Method.	3,5 9

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
NED: Beneficial Impacts Sources of Costs	N/A		Annual Interest, Amortization, and Operations and Maintenance cost relate to the project activities of Icebreaking, Lock Modifications, Dredging, Ice Control Structures, Compensating Works, Aids to Navigation, etc., as listed in Appendix B.	-	Same as NED Plan, as listed in Appnedix B, with the addition of all costs of the Environmental Plan of Action.	
NED: Adverse Impacts Parameters of Impacts	N/A	+	Most of these costs will be borne by Federal agencies (U.S. Army Corps of Engineers, U.S. Coast Guard, St. Lawrence Seaway Development Corporation, National Oceanic and Atmospheric Administration). Most costs of harbor improvements will be borne by local agencies. See Appendix B for a breakdown.	+ 2,6 9	Same as NED Plan, in addition the costs of the Environmental Plan of Action will be borne by Federal agencies. Specific costs and agencies responsible for studies are yet to be determined.	2,6 9
TOTAL INVESTMENT COSTS - NED	None		$450,969,000	2,6 9		2,6 9
BENEFIT/COST RATIO	None		4.0	2,6 9		2,6 9

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

FULFILLMENT-PROJECT CRITERIA OBJECTIVES: ECONOMIC	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
a. Project dollar benefits should exceed project dollar costs.	N/A	+	High	+	High	+
b. Separable units of improvement should provide dollar benefits at least equal to its dollar cost.	N/A		High		High	
c. The scope of the development should be such as to provide...certainly identify...the maximum net benefits.	N/A		High		Medium	
d. Annual costs including operation and maintenance should be based upon a 50-year economic life and an interest rate of 7-1/8 percent.	N/A		High		High	
e. There should be no more economically or environmentally acceptable means accomplishing the same purpose or purposes that would be precluded from development if the plan were undertaken.	Does not serve purpose of navigation season extension.		Most economically acceptable means		Most environmentally acceptable means, if the authority provides for conduct of environmental studies preceeding project construction and operation.	
f. Projected project disbenefits, and environmental and social costs must be included, and if possible quantified.	N/A		High		High	

+See Index of Footnotes on Page B-38

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
2. ACCOUNTS: ENVIRONMENTAL QUALITY (EQ)						
a. Beneficial Impacts (Enhanced)	Minimal	1,5 11	Minimal	1,5 11	Implementation of the Adaptive Method under this alternative will stuive, where possible, for project modification which will achieve the planning objectives, and enhance or maintain the environmental quality of the Great Lakes-St. Lawrence Seaway System.	1,5 10
b. Adverse Impacts (Degraded/Destroyed)						
Air Quality*	Vessel smog extends into winter months.	1,5	Due to increased vessel activity, an increase in contaminate level could arise throughout the region, particularly in harbors and connecting channels. It should be noted that the extension of the shipping season would alter the distribution of vessel traffic, distributing the traffic more evenly throughout the year. In some instances, adverse impacts to Air Quality may be lessened in harbors, as summer vessel traffic would be less concentrated than with the No Action Plan.	1,5	Same as NED Plan.	1,5 9

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
EQ: Adverse Impacts						
Noise*	Noise in harbors and connecting channels from vessel activities continue on into the winter.	1,5	Noise in harbors and connecting channels would be evident for a longer period than "No Action."	1,4 9	Same as NED Plan.	1,5 9
	Vessel crews subjected to noise of vessel moving through ice-covered waters.		Vessel crew subjected to noise of moving through ice-covered waters for longer period of time than "No Action."		Implementation of EPOA would identify any special problem areas related to vibrations and thus could lead to vessel rerouting or vessel speed adjustment to reduce vibration related problems.	
	Transmission of vibrations directly to shore and shore structures by vessels moving in solid ice-covered constricted areas. (Evidenced only in the St. Marys River).		Vessels moving in solid ice-covered constricted areas could transmit vibrations directly to shore and shore structures, for a longer period.			
Water Quality*	Danger of oil spill accidents from vessels moving in ice-covered waters.		Continued potential danger of oil/hazardous material spill by longer operation.	1,5 9	Same as NED Plan, however, where significant adverse impacts are identified, mitigation measures as considered necessary would be recommended.	1,5 9,10
			Changes to local water quality in connecting channels and harbors may increase, level unknown. While potentially increasing the total adverse effects to water quality, redistribution of traffic from traditional navigation season to the extended season may decrease the magnitude of effects on a local basis.			
			No large scale changes caused by air bubblers and possible resultant open water.			

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
EQ: Adverse Impacts						
Water Levels and Flows	Ice jams in lower St. Clair River occur depending upon meteorological conditions. Records show jams to be minimal during December and January.		Ice jam potential increases. Remainder of winter, impact to be be mitigated by ice stabilization structures. However, the ice stabilization structures (St. Clair and Detroit River) by decreasing ice retardation could increase flows. This could require compensating works to maintain 'normal' flow condition and water level.		Same as NED Plan. See ELD Plan for Water Quality, above.	
Sediment Transport and Shore Erosion	Continuance of natural shore erosion and sedimentation in the lakes and connecting channels. Potential damage in constricted channels due to vessel movement.	1,2 3,5 9	Same as No Action Plan. Construction effects on sedimentation for dredging - short term. Expected recovery long-term. Shoreline protection would be provided for those impacts which have been identified from actual operations.	1,2,3 5,9	Same as NED Plan. Reduced potential of shore erosion and sedimentation by shore protection in critical areas of the rivers. Restrict vessel speeds past erodible areas. Further detailed investigation of possible shore erosion sites in the entire system is required.	1,2 3,5 9,10
Shore Erosion and Structure Damage	Adverse effects along ice-covered connecting channels (St. Marys and St. Clair Rivers). Continuation and aggravation of natural shore erosion along the St. Marys River.	1,2 3,5 9	Increased damage possible to unprotected dock facilities beyond that caused by natural conditions. Erosion may increase, adding to natural erosion. This adverse effect would be greatest in shallower areas and in narrow channels.	1,2, 3,5 9	Damage expected to exist. However, use of shore protection measures and fracture line piling would mitigate damage due to extended season, traditional season, and natural causes. Restrict vessel speeds past erodible areas.	1,2 3,5 9,10
+See Index of Footnotes on Page B-38 *Asterisk indicates Section 122 effects.						

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
EQ: Adverse Impacts					
Oil/Hazardous Substance		Increased vessel activity would increase the potential for oil/hazardous substance spill. Clean up of oil/hazardous materials could be more difficult during winter months. An oil spill would cause adverse environmental effect wherever it occured in the System depending on the volume spilled, substance, timing, weather, location, recovery techniques and currents. Depending on the substance, physical and/or biological resources may be degraded or destroyed.	1,2 3,5 9	Same as NED Plan, however, the Adaptive Method proposes continued improvement in technology, contingency plans, and equipment to afford the level of protection that would be required.	1,2 3,5 9
Coastal Zones (Every applicant for Federal license or permit for an activity in the Coastal Zone must obtain a certification from the State that the proposed activity complies with the State's Coastal Zone Management Program.)	Not Established	Coastal Zone Management Act of 1972, dictates that the plans and activities of the navigation extension program be in conformity with the objectives of State approved plans. At present, Michigan and Wisconsin have approved programs, and the proposed navigation extension plan must meet compliance. A determination of compliance with The Michigan Coastal Zone Management Plan has not been made due to lack of environmental baseline data and assessment.	1,5 9	Upon completion of environmental baseline data gathering prior to initiation of the winter navigation extension program, probability of compliance with State approved plans is likely.	1,5 9,10

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
EQ: Adverse Impacts						
Benthic Communities	Impacts caused by vessel operations due to physical alterations (e.g. abrasion and scour of sediment. Significance not established.	1,5 9	Same as No Action Plan. Additional destruction to benthos by dredging to widen and deepen channels.	1,5 9	Same as NED Plan. Additional studies would establish significance and would recommend mitigative measures if necessary.	1,5 9
Vegetation	Icebreaking and vessel operations in constricted areas can result in lateral and vertical movement of ice adjacent to shorelines. This ice movement can degrade some wetland or aquatic vegetation. Significance not established.	1,5 9	Same as No Action Plan. Increase in magnitude of impact expected due to increased operational time. Restricted to channels and harbors.	1,5 9	Same as NED Plan. Additional studies would establish significance and would recommend mitigative measures if necessary.	1,5 9
Fisheries Resource	Various vessel activities influence fish spawning, egg survival, behavior, distribution and habitats in St. Marys River and some harbors.		Could be affected through various program activities. The program activities in areas such as connecting channels, harbors, and shallow water areas of lakes could influence fish spawning, egg survival, behavior, distribution and habitats. These potential effects, if significant, could alter a fisheries rescurce of a lake.	1,4 9	Same as NED Plan. Detailed assessments required to evaluate impacts. The Adaptive Method, through the EPOA, would evaluate the effects of the project activities, the need for protection of certain areas, and explore the need for mitigation measures. Fish spawning and nursery atlas currently being prepared.	1,4 9,10

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
EQ: Adverse Impacts						
Wildlife Resources	Migration of mammals that use ice cover for crossing water barriers could be affected during December and January operations. Vessel traffic could alter winter waterfowl habitat and waterfowl behavior patterns.	1,5 9	See No Action Plan. Construction activities, dredging, and continued vessel operation could eliminate, degrade, or enhance wildlife habitat resources.	1,5 9	See NED Plan. Detailed assessments required to evaluate impacts. The Adaptive Method, through the EPOA, would evaluate the effects of the program activities, the need for protection of certain areas, and explore the need for mitigative measures. A study "Impact of Winter Navigation on Migratory Birds in the Great Lakes/St. Lawrence Seaway" is currently underway.	1,5 9,
Endangered/Threatened Species	Potential Impact to the Gray Wolf and Bald Eagle. Section 7 coordination not initiated for 31 January season extension. (Required before implementation) (St. Marys River).	1,5 9	Same as No Action Plan. In addition, increased potential for impact due to increase in magnitude and presistence of program activities. Biological assessment is required.	1,5 9	Same as NED Plan. Biological assessment required for the confined areas of the Great Lake - St. Lawrence Seaway System (Rivers). The Adaptive Method through the EPOA, would evaluate the potential effects of the program activities, and the need for protection measures.	1,5 10

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

FULFILLMENT-PROJECT CRITERIA OBJECTIVES: ENVIRONMENTAL	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
a. Provide for management, protection, or enhancement of ecological systems.	Low		Low		High	
b. Provide for management, preservation, or enhancement of specially valuable or outstanding archaeological, historical, biological or geological resources.	Low		Low		High	
c. Provide for enhancement of quality aspects of water, land, and air by control of pollution or prevention of erosion and restoration of already eroded areas caused by winter navigation.	Low		Medium		High	
d. Provide for management, protection, or enchancement of aesthetic areas.	Low		Low		Low	
e. Provide for avoidance of unnecessary irreversible commitment of resources to future use.	Low		Medium		High	

+See Index of Footnotes on Page B-38

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
3. ACCOUNTS: SOCIAL WELL BEING (SWB)						
Aesthetic Values*	No Change		There would be a temporary effect during installation and removal of mitigative measures (i.e. icebooms, bubbler flushers, rock filled scows, and crane weights crib). Vessel passage during the winter would be less than that occurring during the previous normal season (1 April to 15 January, $\pm$ 2 weeks, as the entire fleet is not equipped to operate under winter conditions. This effect would be less than what occurs during the normal season due to reduced vessel activity and noise in the harbors, locks, and connecting channels. For those who enjoy watching the passing vessels this would be a beneficial impact, and for those who find winter vessel passage objectionable, this would be an adverse impact.	6	Same as NED Plan.	6
Community Cohesion*	No Change		No significant effects, except as noted under Cross Channel Transportation.		Same as NED Plan.	
Availability of Public Service Facilities*	No Change		No significant effects, however, additional harbor facilities and services would be required.		No significant effects, Same as NED Plan.	
Displacement of People, Businesses and Farms*	No Effect		No significant effects.		No significant effects.	

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
SWB						
Damages Above the High Water Mark (Shore Erosion and Shore Structure Damage).	No Effect		Liability for damages to be determined by litigation.	2,5 9	Same as NED Plan.	2,5 9
Recreation and Leisure Activities.	No Effect		Recreational activities in harbors and connecting channels would be interrupted as the navigation channel would be periodically opened for vessel passage. This would not interrupt recreational activities occurring at a safe and reasonable distance from the actual navigation channel (the distance will vary throughout the season as weather conditions change).	6	Same as NED Plan.	6
Cross Channel Transportation	No Change		The opening of the vessel tracks during the winter would interfere with some traditional modes of crossing the connecting channels (i.e. car ferries, walking across the ice cover, and snowmobiles). Areas of impact would be in the St. Marys, St. Clair, and St. Lawrence Rivers. Mitigative measures are necessary to provide for more regular and safe channel crossing, (such as extended operation of	6	Same as NED Plan.	6

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
SWB		+		+		+
Cross Channel Transportation (Cont.)			the Lime Island Airboat, Sugar Island Ferry bubbler-flusher, and tug operation at Grindstone Island). Reinstallation of the ice boom in the St. Marys River plus the installation of ice booms in the St. Lawrence River and at the head of the St. Clair River would enhance ice-cover stability, helping to mitigate most island transportation problems.			
Occupational Groups	No Effect		Potential for hazardous conditions to pilot, vessel crews, lock and terminal personnel would be reduced through use of on-board and shore navigation aids vessel reporting systems, reconnaissance and information dissemination systems.	6	Same as NED Plan.	6

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

FULFILLMENT-PROJECT CRITERIA OBJECTIVES: SOCIAL	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
		+		+		+
a. Avoid unnecessary and/or unreasonable risk or loss life and hazard to health and safety.	No Effect		High		High	
b. Preserve or enhance social cultural, educational and historical values.	No Effect		Medium		Medium	
c. Avoid disruption of manmade or natural resources, aesthetic values, community cohesion, and public facilities and services.	High		Medium		Medium	
d. Consider human environmental benefits and costs equal in status to monetary untis.	N/A		Medium		High	
e. Identify possible employment effects and changes to tax and property values.	Low		High		High	
f. Coordinate alternatives with local, regional and State interests.	Low		High		High	
g. Evaluate public acceptance of proposed modifications and ability and willingness to meet local requirements.	Low		Medium		High	

+See Index of Footnotes on Page B-38

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
4. ACCOUNTS: REGIONAL DEVELOPMENT (RD)						
Employment Effects*	Continuation of current trends.		Net increase of approximately $1 billion in labor earnings in the year 2020, in the Great Lakes region. Increase of about 42,000 jobs in the region by 1990.	2,6 9	Same as NED Plan	2,6 9
Tax and Property Values*	Continuation of current trends.		Increase in property values of commercial sites, such as harbors, and in industrial areas which benefit from the economic gains of this plan. Property values of residential sites (riparians) could be adversely effected especially in narrow channels where erosion and shore structure damage is amplified. Mitigative/protective measures are being recommended.	2,6 9	Same as NED Plan.	2,6 9
Regional Growth	No Estimate		Increases in all categories: - direct economic benefits (due to port activity) - other economic benefits (due to multiplier effect - See Appendix D, Regional Multipliers) - household consumption expenditures in the region. NED Plan would increase port jobs: Longshoremen Stevedores Seaman Repair Personnel	2,6 9	Same as NED Plan.	2,6 9

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

EFFECTS/IMPACTS*	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
RD						
Regional Growth (Cont.)			Freight Agents Ship Pilots Port Administrators (See Appendix D) Increases in regional transportation savings.			

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

PLANNING EVALUATION CRITERIA	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
1. Acceptability	High		Objections to the NED Plan have made season extension on the Great Lakes and St. Lawrence Seaway System a controversial issue. Governmental, organizational, and individual environmental concerns have raised objections to the extension to the of the season. Opposition has been voiced by others, including the State of New York, the N.Y. Department of Environmental Conservation, power entities, sport groups, and tourism concerns. Riparians, affected island residents, freight railroads and State Coastal Zone Management agencies have raised issues of concern. Certain Congressmen, Great Lakes State Governors, trade unions as well as some private citizens are opposed to the extension of navigation. Those who are in favor of the season extension include industrial interests, including those of steel, grain, power, petroleum and mining. Domestic and foreign shippers (import and export) and ship owners and operators, the St. Lawrence Seaway Authority, and port authorities support the program. Proponents also include some Congressmen, Great Lakes States Governors, trade unions, and some private citizens.		Same as NED Plan. The extensive environmental evaluations proposed under this plan are designed to assure the protection or enhancement of the environment during post-authorization planning, design, construction, and operation. Acceptability of the EQ Oriented Plan is likely to be high, as it responds to environmental concerns.	

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont)
SYSTEM OF ACCOUNTS

PLANNING EVALUATION CRITERIA	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE		NATIONAL ECONOMIC DEVELOPMENT NED PLAN		ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	
1. Acceptability (Cont.)		+	Others have expressed concern, remain uncommitted, or would be in support of the program should environmental studies be conducted prior to initial of construction or operations. (The major issues of contention, pro and con, are discussed in this System of Accounts.)	+		+
2. Completeness	N/A		Due to the International nature of the Great Lakes and St. Lawrence Seaway System, Canadian coordination and co-participation is *necessary for implementing a systemwide* navigation season extension project. Formal Canadian co-participation does not yet exist. Further coordination with Canadian agencies may be intiated upon signal from the Congress, such as passage of some new season extension authorization or when determined propitious by the Administration. A precise date for such actions cannot yet be determined, but the beginning of operations on International portions of the system would depend on consultation with the Canadian Government. *Also, see Coastal Zone Management* Environmental Quality in System of Accounts.		Cannot estimate - additional *environmental studies may* prove necessary.	

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

PLANNING EVALUATION CRITERIA	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
3. Effectiveness	N/A		Technically Feasible, however this Plan lacks the programs to assure the protection or enhancement of the environment. Also, see Coastal Zone under the EQ Account.		Technical feasible.	
4. Efficiency	N/A		Least costly means of obtaining output of plan.		Most costly plan.	
5. Certainty	High		Plan most likely to fulfill NED Plan objectives.		Plan most likely to fulfill EQ Plan objectives and most NED objectives.	
6. Geographical Scope	Four upper Great Lakes and their connecting channels.		Great Lakes Region (five Great Lakes and their connecting channels and the International Section of the St. Lawrence River) and to a lesser extent, the nation.		Same	
7. NED Benefit/Cost Ratio	N/A				Equal to NED Plan or less than NED Plan depending on the amount of mitigative measures necessitated by EPOA.	
8. Reversibility	N/A		Least reversible with respect to environmental quality.		Best reversibility potential due to data obtained in environmental studies.	
9. Stability	High		Medium		Medium	
10. Institutional	N/A		High		High	
11. Technical	N/A		Medium		High: Unlike the NED Plan, the EQ Oriented Plan provides technical solutions with the least adverse environmental inputs, and corrective and/or mitigative measures are a part of engineering solutions.	

+See Index of Footnotes on Page B-38
*Asterisk indicates Section 122 effects.

TABLE B-2 (Cont.)
SYSTEM OF ACCOUNTS

FULFILLMENT - PROJECT CRITERIA/OBJECTIVES PROJECT PLANNING OBJECTIVES	NO ACTION PLAN "WITHOUT CONDITION" - MOST PROBABLE ALTERNATE FUTURE	+	NATIONAL ECONOMIC DEVELOPMENT NED PLAN	+	ENVIRONMENTAL QUALITY EQ ORIENTED PLAN	+
a. Provide a navigation plan which uses the water and land resources of the Great Lakes - St. Lawrence Seaway System in a manner which is most acceptable to and best accommodates public and professional concerns.	Low		Medium		High	
b. To develop a navigation plan for the entire Great Lakes-St. Lawrence Seaway System which will enhance national economic development and environmental quality and will contribute to regional development and the social well-being of the entire 19-State Great Lakes economic area.	Low		High - enhanced NED. Medium - enhanced EQ.		High - enhanced NED and EQ	
c. To develop a navigation plan for the entire system whereby navigation will not negatively impact upon power production and riparian owners.	High		Medium		Medium	
d. To make better use of the water transportation system and its facilities for both bulk and general cargo vessels without unacceptable environmental degredation.	Low		Medium		High	
e. To enhance year-round overseas trade, which will in turn enhance production income, and employment in the Great Lakes region.	Low		High		High	

+See Index of Footnotes on Page B-38

TABLE B-2 (Cont.)
INDEX OF FOOTNOTES

TIMING

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

UNCERTAINTY

4. The uncertainty associated with the impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

EXCLUSIVITY

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

ACTUALITY

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

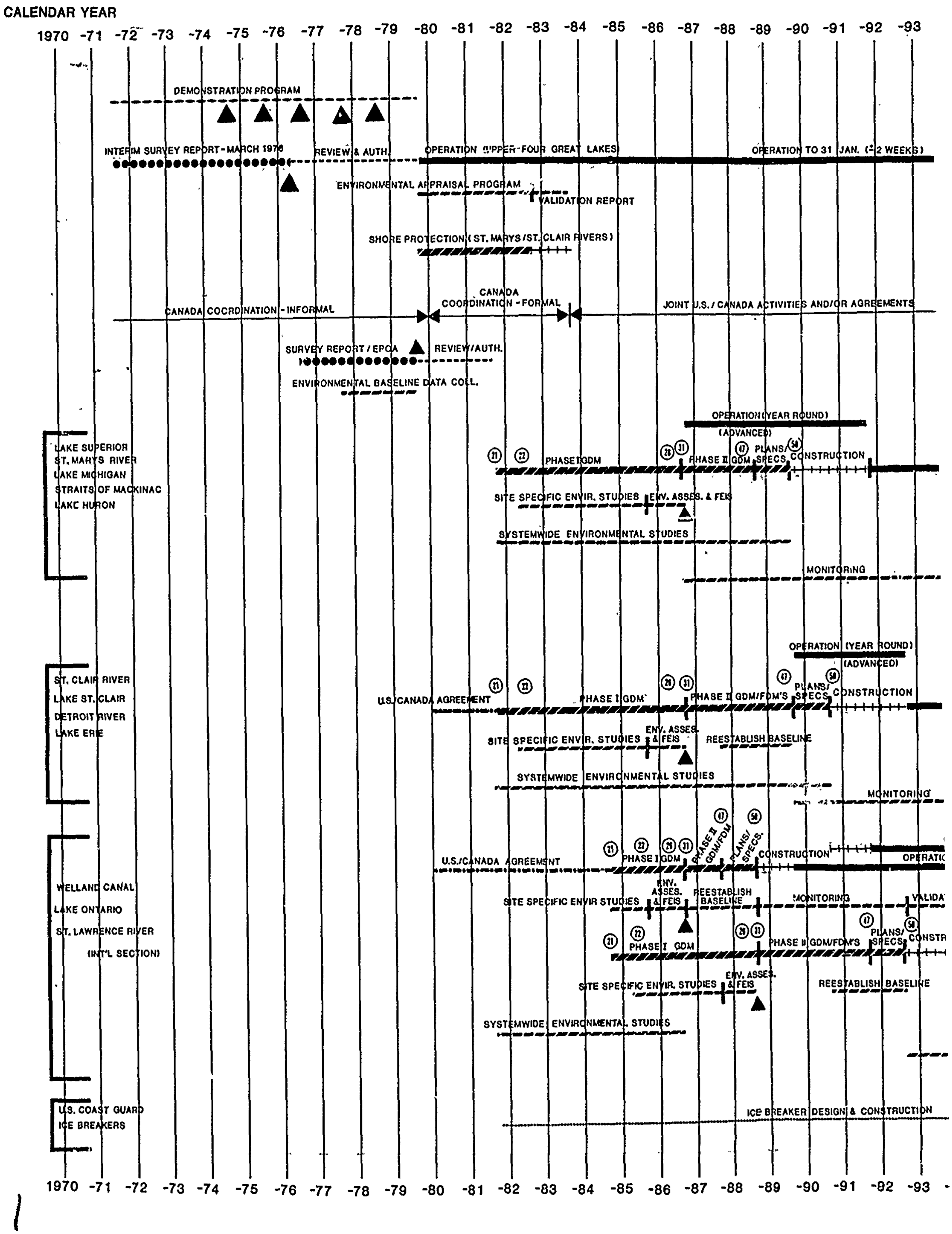
PHASED IMPLEMENTATION

Because of the complexity and vastness of the Great Lakes-St. Lawrence Seaway System and the need for Canadian co-participation, phased implementation of the project is considered absolutely necessary. This particularly applies to the St. Clair and Detroit River system, Welland Canal (all Canadian), and the St. Lawrence River, a major part of which is wholly in Canada. On the St. Clair and Detroit River systems, improvements being recommended for these reaches are necessary to minimize risks cross the international boundary. Without Canadian co-participation in the Welland Canal, on the Canadian reach and International section of the St. Lawrence River, navigation season extension on the total Great Lakes/St. Lawrence Seaway system cannot be realized.

This report is based upon the assumption that the recommendations in the Chief of Engineers Report, dated 16 November 1977, which was transmitted to Congress for its information on 3 August 1979 (House Document No. 96-181), would be implemented prior to initiation of the recommendations in this report.

Phased implementation means the implementation of a permanent navigation season program above and beyond the base condition in this report in a selected time and geographical sequence. This sequence is the same as the one displayed in Table 1 and is displayed graphically in Plate B-1. Season extension would likely be implemented in the same sequence as Proposal 1 through Proposal 6. Benefit-cost analyses have been done for each of the six proposals and are displayed in detail in Appendix D - Economic Benefits and Costs. It shows incremental justification for the step-by-step or phased implementation process.

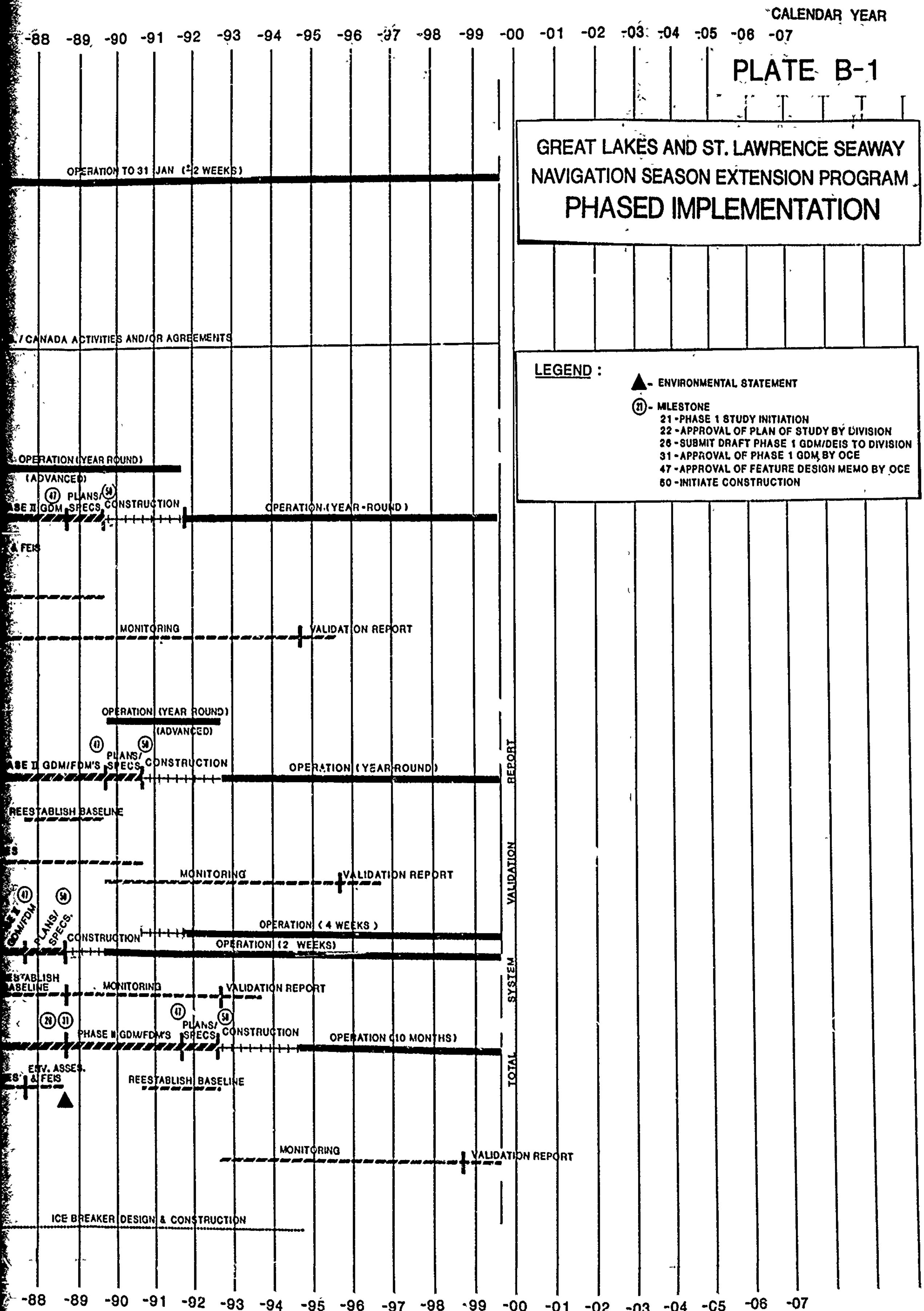
The actual procedure for implementation of activities associated with each phase is described in the section entitled "Adaptive Method."



CALENDAR YEAR
1970 -71 -72 -73 -74 -75 -76 -77 -78 -79 -80 -81 -82 -83 -84 -85 -86 -87 -88 -89 -90 -91 -92 -93
DEMONSTRATION PROGRAM
INTERIM SURVEY REPORT - MARCH 1976
REVIEW & AUTH.
OPERATION UPPER FOUR GREAT LAKES
OPERATION TO 31 JAN. (±2 WEEKS)
ENVIRONMENTAL APPRAISAL PROGRAM
VALIDATION REPORT
SHORE PROTECTION (ST. MARYS/ST. CLAIR RIVERS)
CANADA COORDINATION - INFORMAL
CANADA COORDINATION - FORMAL
JOINT U.S./CANADA ACTIVITIES AND/OR AGREEMENTS
SURVEY REPORT / EPOA
REVIEW/AUTH.
ENVIRONMENTAL BASELINE DATA COLL.
LAKE SUPERIOR
ST. MARYS RIVER
LAKE MICHIGAN
STRAITS OF MACKINAC
LAKE HURON
OPERATION (YEAR ROUND) (ADVANCED)
PHASE I GDM
PHASE II GDM
PLANS/SPECS
CONSTRUCTION
SITE SPECIFIC ENVIR. STUDIES
ENV. ASSES. & FEIS
SYSTEMWIDE ENVIRONMENTAL STUDIES
MONITORING
ST. CLAIR RIVER
LAKE ST. CLAIR
DETROIT RIVER
LAKE ERIE
OPERATION (YEAR ROUND) (ADVANCED)
U.S./CANADA AGREEMENT
PHASE I GDM
PHASE II GDM/FDM'S
PLANS/SPECS
CONSTRUCTION
SITE SPECIFIC ENVIR. STUDIES
ENV. ASSES. & FEIS
REESTABLISH BASELINE
SYSTEMWIDE ENVIRONMENTAL STUDIES
MONITORING
WELLAND CANAL
LAKE ONTARIO
ST. LAWRENCE RIVER
(INT'L SECTION)
U.S./CANADA AGREEMENT
PHASE I GDM
PHASE II GDM/FDM
PLANS/SPECS.
CONSTRUCTION
OPERATIC
SITE SPECIFIC ENVIR STUDIES
ENV. ASSES. & FEIS
REESTABLISH BASELINE
MONITORING
VALIDA
PHASE I GDM
PHASE II GDM/FDM'S
PLANS/SPECS
CONSTR
SITE SPECIFIC ENVIR. STUDIES
ENV. ASSES. & FEIS
REESTABLISH BASELINE
SYSTEMWIDE ENVIRONMENTAL STUDIES
U.S. COAST GUARD
ICE BREAKERS
ICE BREAKER DESIGN & CONSTRUCTION
1970 -71 -72 -73 -74 -75 -76 -77 -78 -79 -80 -81 -82 -83 -84 -85 -86 -87 -88 -89 -90 -91 -92 -93

PLATE B-1

GREAT LAKES AND ST. LAWRENCE SEAWAY
NAVIGATION SEASON EXTENSION PROGRAM
PHASED IMPLEMENTATION



LEGEND :

▲ - ENVIRONMENTAL STATEMENT

(21) - MILESTONE
21 - PHASE 1 STUDY INITIATION
22 - APPROVAL OF PLAN OF STUDY BY DIVISION
26 - SUBMIT DRAFT PHASE 1 GDM/DEIS TO DIVISION
31 - APPROVAL OF PHASE 1 GDM BY OCE
47 - APPROVAL OF FEATURE DESIGN MEMO BY OCE
50 - INITIATE CONSTRUCTION

2

The first phase (Proposal 1) would be implementation of those measures required for year-round navigation on the upper three Great Lakes (Superior, Michigan and Huron). It should be noted that after environmental investigations are concluded and the environmental statement submitted for the Phase I General Design Memorandum, existing facilities may allow for early vessel operations in advance of completion of construction of all improvements for this phase.

The second phase (Proposal 2) would be implementation of measures required to provide a 15-day extended closing on the Welland Canal-Lake Ontario-St. Lawrence River reach to 31 December.

The third phase (Proposal 3) would be the implementation of measures required to provide up to year-round navigation on the St. Clair/Detroit Rivers and Lake Erie.

The fourth phase (Proposal 4) would be the implementation of measures required to provide for approximately an eleven day early opening starting 20 March on the St. Lawrence River and use of the Welland Canal.

The fifth phase (Proposal 5) considers 10-month navigation from approximately 7 March to 7 January on the St. Lawrence River portion of the system and use of the Welland Canal.

The sixth phase (Proposal 6) considers 11-month navigation on the St. Lawrence River from approximately 7 February to 7 January, and use of the Welland Canal.

ADAPTIVE METHOD

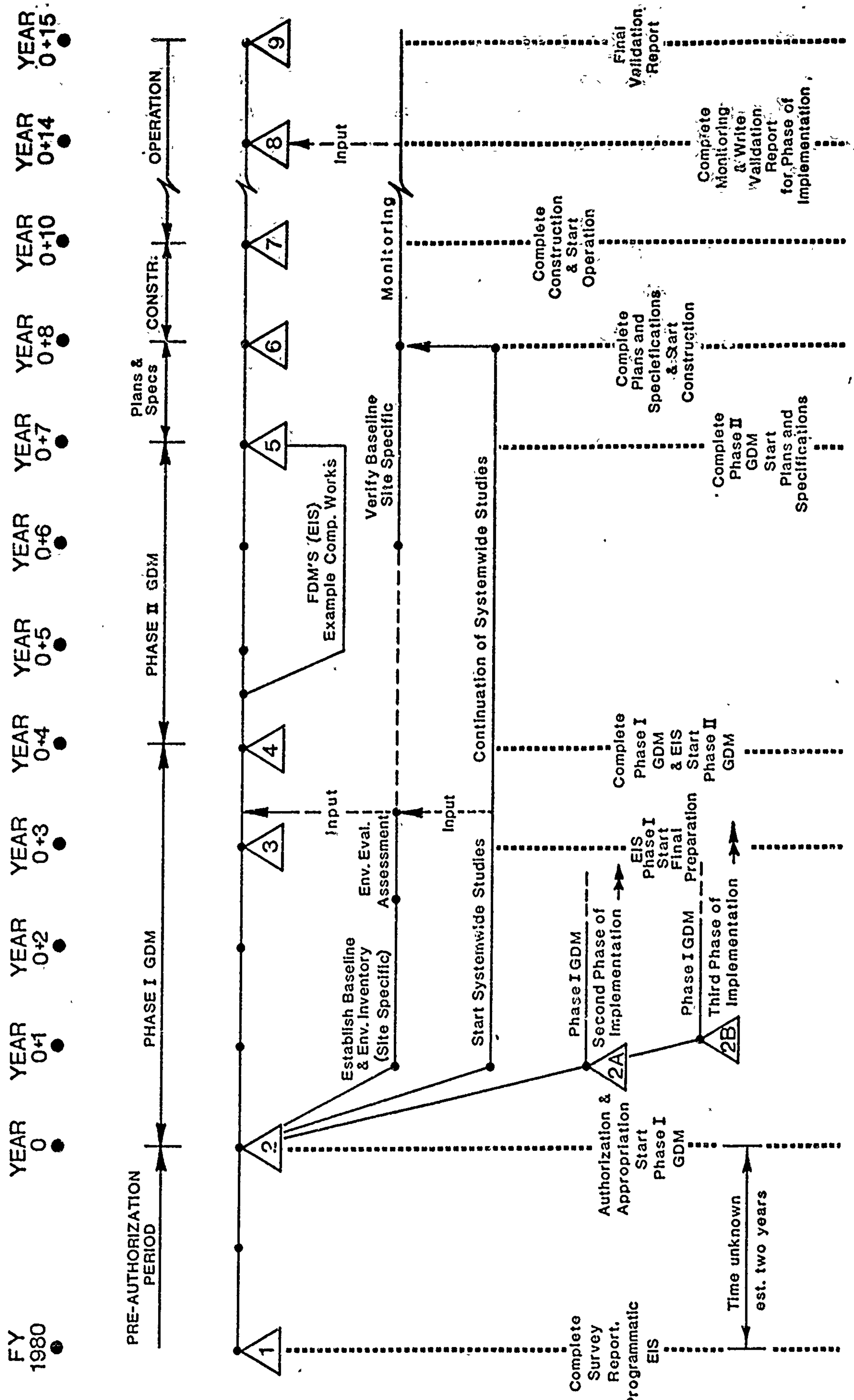
The Environmental Impact Statement (EIS) accompanying this Survey Report is programmatic in nature. It describes currently known

environmental impacts that would result from an Extended Navigation Season. It addresses impacts on a regional scale and makes provision for the follow-on studies as described in this Environmental Plan of Action (EPOA). The EIS because of its programmatic nature also is able to address potential, perceived, and unforeseen impacts and provides a proposed plan for determining which of these might actually occur (i.e., EPOA). The EIS, by means of this EPOA, presents the environmental program for best assuring that the environment of the Great Lakes System would be protected adequately during development of an Extended Navigation Season Program. The environmental program contains a plan called the Adaptive Method, which provides the necessary checks and balances to best assure protection of the environment. Predictions of environmental impacts would be accomplished through the use of U.S. Fish and Wildlife Service Assessment Methodology Technique, which is an integral part of the Environmental Plan of Action. For the level of detail available for this Survey Report, the Programmatic EIS is considered adequate and appropriate.

An understanding of the Adaptive Method can best be gained through reviewing the text below and referring to the diagram in Plate B-2. That diagram outlines the plan, showing basic time frames, reports required, and inherent checks and balances.

Triangle 1 represents completion of this Survey Report which is scheduled for early 1980. Triangle 2 represents an anticipated Congressional authorization and appropriation of funds which could occur about 1982, should Congress authorize the recommended plan for continued planning, design, and construction. Since the actual time for such authorization is unknown, the schedule on the diagram designates this point as year zero for scheduling subsequent activities and reports.

At year zero, following appropriations, Corps of Engineers (COE) would begin several geographically oriented detailed planning studies



ADAPTIVE METHOD DIAGRAM

Plate B-2

concurrently with obtaining environmental baseline and inventory data and initiating the system-wide and site specific studies. After a period of up to 3 to 5 years, sufficient information (environmental, engineering, etc.) would be developed to make engineering decisions and to allow preparation of the integrated environmental, economic, and engineering decision-making document called an EIS which would accompany its mutually supporting Phase I General Design Memorandum (GDM) to higher COE authority for approval. This EIS would be based on evaluation of the baseline data from both site specific and system-wide studies. Using the Fish and Wildlife Service (FWS) Assessment Methodology Technique, the EIS would predict all impacts known at that time resulting from the Extended Navigation Season Program, and would provide details on monitoring considered necessary to guard against unanticipated adverse impacts. On the diagram, the assessment and impact prediction would occur between Triangles 3 and 4.

Also, key to understanding the COE Adaptive Method is the commitment that should the assessment indicate a need, the design of an item or planned activity could be modified during Phase I planning to mitigate, compensate, or eliminate adverse impacts.

After approval of the Phase I GDM and EIS, Phase II studies would begin which are detailed engineering design studies leading to preparation of plans and specifications. System-wide studies would continue during this period. At some point, about two years before any construction is scheduled to begin (Triangle 6), the environmental baseline would be verified and updated in preparation for monitoring during construction and operation. Should the design be significantly altered or new information be developed showing a probability of a previously unanticipated impact, an appropriate update to the EIS would be prepared prior to construction. In addition, it is likely that for a major construction activity, such as compensating works, a Feature Design Memorandum (FDM) would be prepared. This FDM would describe only one item of construction and could also require the preparation of an environmental assessment or EIS if the

structure were altered significantly from previously described plans or if new potential impacts of the structure came to light since the previous EIS was completed.

During construction and operation (Triangle 7 through 9), environmental monitoring would be accomplished as a check on impact predictions and as a safeguard against unanticipated adverse impacts. The monitoring would compare the post-construction environmental base conditions with pre-construction conditions. This would detect subtle or cumulative impacts. Should the monitoring indicate that a significant impact is occurring, any of several things would be done depending on the nature of the impact. If the impact was found unacceptable, the cause would be eliminated, even to the halting of vessel traffic. If a lesser measure would accomplish a satisfactory result, it would be done. If an impact develops which is considered acceptable but undesirable, appropriate measures would be taken to mitigate, compensate, or eliminate the impact without halting vessel transits.

There would be several Phase I (GDM) studies and EIS's running concurrently, but these would not necessarily be started simultaneously. The diagram, for clarity, shows only one phase of the recommended implementation and represents the effort needed for year-round navigation on the upper four Great Lakes. An example of another phase of implementation would be that of achieving 10-month navigation on the St. Lawrence River.

A Validation Report would be completed for each phase of implementation. A Final Validation Report would be written summarizing all preceding reports. These would be prepared after monitoring indicated that all impacts had been identified and evaluated and all efforts at compensating, eliminating, or mitigating impacts had been taken. The Validation Reports would review the information obtained and recommend whether or not operation should continue. The Final Validation Report

would provide the answer on the environmental acceptability of the extended navigation season program or any phase of the program.

Variations from Project Implementation Procedures.

The Adaptive Method process differs from standard COE procedures in four (4) areas:

(1) The Environmental Impact Statement (EIS) is programmatic in nature, addressing the impacts of the entire program on a level consistent with present knowledge, and supportive of, the engineering studies. The programmatic EIS addresses impacts on a regional scale and describes the program for determining details of site-specific and system-wide impacts at appropriate times during post-authorization and pre-construction studies which would address affirmation or reformulation, if necessary.

(2) The Fish and Wildlife Service Environmental Assessment Technique is employed to extend the customary assessment process, made in the planning phase, through construction and operation. It places increased emphasis on responding to unforeseen adverse impacts that occur during project detailed design, construction, and operation. This technique should provide for better management responses to unanticipated adverse environmental impacts.

(3) The Validation Report is a summary of evaluations and conclusions reached during the monitoring phase of the Program. This is a new type of report, not previously accomplished in COE studies, and would be provided to the Congress. It would provide a vehicle for recommending that the extended navigation season program be modified or halted, based on unacceptable environmental impacts.

(4) The estimated cost of environmental studies is $126 million, and is higher than that previously experienced for site-specific, water

resource development projects. The factors which contribute to the cost are a lack of adequate information on the Great Lakes-St. Lawrence River winter ecosystems and other effects associated with navigation through ice.

EVALUATION OF PROPOSALS

Economic Benefits and Costs

The economic feasibility of each of the six proposals to extend the navigation season was determined by comparing equivalent average annual charges; i.e., interest, amortization, and operations and maintenance costs, with an estimate of the average transportation-related annual benefits that would accrue over the selected 1987-2037 period of analysis. The value given to benefits and costs at the time of their accrual was made comparable by conversion to an equivalent time basis using an interest rate of 7-1/8 percent, the current rate applicable to public projects. Costs are based on October 1979 price levels. It is suggested that the reader review Appendix D, Economic Benefits and Costs, for a detailed description of the economic analysis. No estimate of operational costs has been developed for operating the Welland Canal or Canadian St. Lawrence River locks and channels. Should the Canadian government participate in the extended season program, it is assumed they will operate the Welland Canal and the Canadian St. Lawrence locks and channels. However, the economic evaluation in this report is based solely on U.S. vessel and U.S. harbors related interests. Benefits accrued by Canadian vessels, harbors and shipping interests have not been computed.

Costs of Navigation Season Extension

The entire U.S. portion of the Great Lakes/St. Lawrence Seaway System was analyzed as to the problems and requirements considered necessary to extend the navigation season in the following areas: (1) each of the five

Great Lakes; (2) Great Lakes Connecting Channels; (3) locks in the St. Marys River and International section of the St. Lawrence River; (4) harbors in the entire system; and (5) the St. Lawrence River. A summary of activities necessary to extend navigation season throughout the system is shown in Table B-3 of this Appendix. Costs were derived for all the activities required for each of the six proposals to extend the navigation season throughout the system. In establishing the United States' costs on the Great Lakes boundary waters, two assumptions are made: (1) for the St. Lawrence River, the U.S. will pay 100% of all improvements within U.S. territorial area and 50% of the total cost for facilities bridging the International boundary. In turn, it is assumed that Canada will pay 100% for improvements within its territorial boundaries, and 50% of the total cost for facilities bridging the International boundary; (2) for the St. Clair River-Lake St. Clair-Detroit River System, the U.S. would pay 50% for required ice control structures and compensating works in the system. The U.S./Canada cost split is an initial assumption and is subject to negotiations between the Governments.

Benefits of Navigation Season Extension

Substantial benefits would result from extending the navigation season on the Great Lakes/St. Lawrence Seaway System (GL/SLS). First, shippers of GL/SLS waterborne commerce will have the less costly water transportation alternative open to them for an extended period. This would result in transportation rate savings based on the differentials between GL/SLS winter waterborne rates and alternative overland rates.

The second major area of savings stems from the more efficient utilization of the existing Great Lakes fleet mix under normal winter operations. Navigation season extension provides a greater annual return on the capital invested in ships. Even though variable costs such as fuel and labor may increase with winter navigation, these increases are more than offset by the increased number of loaded trips over which to spread

TABLE B-3
SUMMARY OF ACTIVITIES NECESSARY TO EXTEND THE NAVIGATION SEASON THROUGHOUT THE SYSTEM

Activity	Proposal Number 1	2	3	4	5	6
	(Required number of items included in each activity for each proposal, numbers are cumulative.)					
Icebreakers						
Type B	2	2	4	4	4	4
Type C	10	12	16	18	20	20
Icebreaker Moorings						
Type B	2	2	4	4	4	4
Type C w/dredging	6	7	9	11	12	12
Type C w/o dredging	3	4	6	6	7	7
Vessel Traffic Control	1	1	2	2	2	2
Ice Data Collection 1 Dissemination System	1	1	2	2	2	2
Aids to Navigation	10	14	18	18	18	18
Ice Control Structures	2	4	6	6	11	11
Air Bubbler Systems	6	6	6	6	6	6
Lock Modifications	1	3	3	3	3	3
Dredging	1	1	1	1	1	2
Compensating Works	-	-	2	2	2	2
Shoreline and Shore Structure Protection (Miles of Shore)	4.8	5.9	7.5	8.6	9.6	11.8
Island Transportation Assistance	2	3	3	3	3	3
Water Level Monitoring	1	1	2	2	2	2
Environmental Plan of Action	1	2	3	3	3	3

TABLE B-3 (Continued)

SUMMARY OF ACTIVITIES NECESSARY TO EXTEND THE NAVIGATION SEASON THROUGHOUT THE SYSTEM

Activity	Proposal Number					
	1	2	3	4	5	6
	(Required number of items included in each activity for each proposal, numbers are cumulative.)					
Pilot Access	1	2	3	3	3	3
Ice and Water Forecast	1	1	1	1	1	1
Silver Bay, MN Icebreaking Tug	1	1	1	1	1	1
Duluth-Superior, MN-WI						
Aid to Navigation	6	6	6	6	6	6
Bubblers	13	13	13	13	13	13
Icebreaking Tug	1	1	1	1	1	1
Channel Clearing Craft	1	1	1	1	1	1
Ashland, WI						
Bubbler	1	1	1	1	1	1
Icebreaking Tug	1	1	1	1	1	1
Marquette, MI						
Bubbler	1	1	1	1	1	1
Icebreaking Tug	1	1	1	1	1	1
Escanaba, MI						
Bubblers	5	5	5	5	5	5
Icebreaking Tug	1	1	1	1	1	1
Green Bay, WI						
Navigation Lights	4	4	4	4	4	4
Icebreaking Tug	1	1	1	1	1	1
Calumet, IL						
Bubblers	4	4	4	4	4	4
Indiana Harbor, IN						
Ice Boom	1	1	1	1	1	1
Muskegon, MI						
Ice Boom	1	1	1	1	1	1
Icebreaking Tug	1	1	1	1	1	1

TABLE B-3 (Continued)

SUMMARY OF ACTIVITIES NECESSARY TO EXTEND THE NAVIGATION SEASON THROUGHOUT THE SYSTEM

Activity	Proposal Number 1	2	3	4	5	6
	(Required number of items included in each activity for each proposal, numbers are cumulative.)					
Ludington, MI						
Ice Boom	1	1	1	1	1	1
Icebreaking Tug	1	1	1	1	1	1
Alpena, MI						
Navigation Light	1	1	1	1	1	1
Bubblers	2	2	2	2	2	2
Icebreaking Tug	1	1	1	1	1	1
Saginaw, MI						
Navigation Lights	2	2	2	2	2	2
Ice Boom	1	1	1	1	1	1
Icebreaking Tug	1	1	1	1	1	1
Monroe, MI						
Bubblers	-	-	2	2	2	2
Icebreaking Tug	-	-	1	1	1	1
Toledo, OH						
Aid to Navigation	-	-	1	1	1	1
Icebreaking Tug	-	-	1	1	1	1
Sandusky, OH						
Bubbler	-	-	1	1	1	1
Icebreaking Tug	-	-	1	1	1	1
Huron, OH						
Bubblers	-	-	2	2	2	2
Ice Boom	-	-	1	1	1	1
Icebreaking Tug	-	-	1	1	1	1
Lorain, OH						
Ice Boom	-	-	1	1	1	1
Cleveland, OH						
Ice Boom	-	-	1	1	1	1
Ashtabula, OH						
Ice Boom	-	-	1	1	1	1

TABLE B-3 (Continued)
SUMMARY OF ACTIVITIES NECESSARY TO EXTEND
THE NAVIGATION SEASON THROUGHOUT THE SYSTEM

Activity	Proposal Number 1	2	3	4	5	6
	(Required number of items included in each activity for each proposal, numbers are cumulative.)					
Conneaut, OH Ice Boom	-	-	1	1	1	1
Buffalo, NY Icebreaking Tug	-	-	1	1	1	1

capital costs. Thus, whereas transportation rate savings result from a new least cost alternative defined in terms of existing waterborne and rail rate structures, winter rate savings result from efficiencies in using the current Great Lakes fleet, which lowers the annual freight rate for ships operating in the lakes.

Thirdly, users of bulk commodities such as iron ore and coal, which are transported on the Great Lakes during the 1 April to 15 December navigation season, stockpile resources for winter production needs in addition to contingency needs. Stockpiling savings which would result from a reliable winter supply include interest on capital invested in the stockpile inventory itself and reduction of handling costs incurred in stockpile management.

Summary - Benefits/Costs of Navigation Season Extension

The benefits and costs, described above, and the resulting benefit/cost ratio, for each of the six proposals for navigation season extension on the entire system is shown in Table B-4. Also displayed are the net benefits associated with each of the six proposals. The net benefit is the difference between benefits and costs for each particular proposal.

Environmental Considerations

Environmental considerations include known impacts on the environment, and those impacts which may become potential concerns. Because the winter navigation program is the first of its type in the United States, there is a lack of baseline information concerning biological conditions in the Great Lakes/St. Lawrence Seaway System during the winter months. Biological information was collected during the Demonstration Program; however, it was generally site specific, and investigations fell short of answering all the questions concerning impacts and system-wide environmental feasibility. This circumstance led to the Programmatic EIS and Adaptive Method, previously discussed.

TABLE B-4

AVERAGE ANNUAL BENEFITS AND COSTS (IN $1,000 at 7-1/8%) 24 HOUR OPERATION ON WELLAND-SEAWAY IN WINTER

Avg Annual Benefits	PROPOSAL 1	PROPOSAL 2	PROPOSAL 3	PROPOSAL 4	PROPOSAL 5	PROPOSAL 6 2/
Transp. Rate Savings	92,012	141,883	146,165	162,431	175,022	188,986
Winter Rate Savings	7,350	7,359	7,397	7,405	7,405	7,405
Stockpile Savings	11,996	13,075	21,493	22,695	23,239	23,757
TOTAL	111,358	162,317	175,055	192,531	205,666	220,148
Avg Annual Costs						
Total Investment Cost	239,693	271,182	424,925	431,084	450,969	500,761
Annual Costs:						
Interest & Amortization	17,643	19,960	31,277	31,730	33,194	36,859
Operations & Maintenance	10,317	11,289	17,146	17,840	18,867	19,788
TOTAL	27,960	31,249	48,423	49,570	52,061	56,647
Benefit/Cost Ratio	4.0	5.2	3.6	3.9	4.0	3.9
Net Benefits						
Ben-Costs	83,398	131,068	126,632	142,961	153,605	163,501

1/ Definition of Proposals:

Extended Season Proposals	Estimated Starting Date of Vessel Operations	Lake Superior St. Marys River Lake Michigan Straits of Mackinac Lake Huron	St. Clair River Lake St. Clair Detroit River Lake Erie	Welland Canal Lake Ontario St. Lawrence River
Base Condition	Prior to 1987	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1	1987	Year-round	1 Apr - 31 Jan	1 Apr - 15 Dec
2	1990	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3	1990	Year-round	Year-round	1 Apr - 31 Dec
4	1992	Year-round	Year-round	20 Mar - 31 Dec
5	1995	Year-round	Year-round	7 Mar - 7 Jan
6	2000	Year-round	Year-round	7 Feb - 7 Jan

2/ Based on Minimum Level of Dredging.

Environmental effects of the recommended plan were considered to be minimal in the analysis and evaluation of alternatives considered in the March 1976 Interim Feasibility Report, which recommends navigation season extension to 31 January (± 2 weeks) on only the upper four Great Lakes using fundamentally existing operational measures. However, in response to agency concerns expressed by the Environmental Protection Agency and the U.S. Fish and Wildlife Service, a three-year environmental appraisal program (conducted concurrently with vessel operation during the first three years of operation) was also recommended by the Chief of Engineers in his 16 November 1977 report to validate present environmental assessments through additional data collection, monitoring and evaluation. The Chief of Engineers Report also includes the provision of shore erosion and shore protection measures for the St. Marys River and St. Clair River-Lake St. Clair-Detroit River system which would be implemented as a result of damages caused by extended season operations to 31 January (± 2 weeks) on the upper four Great Lakes.

Since 1976 additional environmental analyses have been conducted relating to air quality, noise, energy, sediment transport and shore erosion, benthic communities, vegetation, fisheries habitat, and wildlife resources. Based on the analyses conducted to date, no significant overriding environmental impacts have been identified which would preclude proceeding with an extended navigation season beyond 31 January (± 2 weeks) on the upper four Great Lakes. However, the state-of-the-art, with available biological information, data, and ecosystem understanding, is not able to provide the total confidence in impact predictions desired at this time. Consideration of the environment in the form of the Adaptive Method (including Phase Implementation) evolved from three basic choices: (1) fully determine environmental feasibility prior to authorization; (2) preliminarily determine environmental feasibility prior to authorization, but conduct comprehensive studies on critical areas following authorization

(but before construction or operation); and (3) preliminarily determine environmental feasibility prior to authorization, conduct any environmental studies on an "as needed" basis during construction or operation. The first possibility has been endorsed by several interest groups and the State of New York. While the alternative itself is the most environmentally conservative, the cost to conduct such studies before determining the exact authorized project bounds is prohibitive. The third possibility, the most environmentally liberal, leaves the environment vulnerable to irreversible losses. The second possibility synthesizes the advantages of the other two -prohibiting a commitment of the environment before the ramifications may be fully discerned, at a reasonable cost.

Studies necessary for this approach are more specifically defined in the Environmental Plan of Action (Appendix E), which could be implemented, in concert with the phased implementation of the six proposals of season extension, during the first 10 to 15 years of the authorized project. The environmental data obtained would be used to refine the activities currently being recommended during the advanced engineering and design phase prior to construction and implementation. If any impacts were found to be significant, provisions would be made for any necessary mitigative or corrective actions, including the halting of vessel traffic if warranted.

RATIONALE FOR RECOMMENDED PLAN

The previous section on plan development discussed the identification of a National Economic Development (NED) plan and an Environmental Quality (EQ Oriented) plan. The NED plan, while maximizing net economic benefits in order to achieve a permanent extension of the navigation season, would not fully satisfy all the planning objectives as set forth for this project study. This is due to the fact that the NED plan would not include a comprehensive Environmental Plan of Action which provides for an ADAPTIVE METHOD approach for determining environmental feasibility of an extended navigation season program and is aimed at enhancing environmental quality

wherever possible. The EQ (Oriented) Plan as described in this report would provide the mechanism to collect sufficient baseline data, evaluate, assess, and address the impact of proposed actions, and monitor and validate on-going actions. This approach would insure the environmental compatibility of the plan of improvement and possibly result in a net enhancement of environmental quality when viewing the system as a whole. A net positive contribution to the environmental quality account would provide for the eventual implementation of a true EQ project plan. The addition of the Environmental Plan of Action and the resulting ADAPTIVE METHOD approach to the basic NED plan should not unacceptably reduce the economic effectiveness of the selected plan. It would also be in much closer conformity to fulfilling all the study planning objectives. As such, it is being recommended that the EQ (Oriented) Plan, as currently described in this report, be selected over the NED plan.

As stated in previous paragraphs, six proposals were developed to further extend the navigation season on the entire Great Lakes/St. Lawrence Seaway System beyond 31 January (± 2 weeks) on the upper four Great Lakes, each to be implemented in sequence called phased implementation. The last step of the proposed phased implementation is Proposal 6 (see Table B-1) - extending the navigation season from 10 to 11 months on Lake Ontario and the International Section of the St. Lawrence River, 12 months on the upper three Great Lakes, and up to 12 months on Lake Erie.

Proposal 5 appears to be the best plan of improvement, and it suggests that the navigation season be extended up to 10 months on Lake Ontario and the International Section of the St. Lawrence River, 12 months on the upper three Great Lakes, and up to 12 months on the St. Clair River-Lake St.Clair-Detroit River System and Lake Erie (Proposal 5). This recommendation is being made with the realization that the ice forming period in the International reach of the St. Lawrence River (above Massena, New York) may not coincide with that in the all Canadian reach below Cornwall, Ontario. As a result, in a given year, the closing date for

navigation on the St. Lawrence River may have to be shifted somewhat to accommodate ice formation in these two reaches under Proposal 5.

Proposal 6 has the following shortcomings:

(1) Uncertainties as to the impacts on water levels and flows during the 11-month in this portion of the system, due to ice control structures and/or dredging.

(2) Eleven-month navigation is currently beyond any plans to extend the navigation season being considered by the Canadian Government.

(3) The question as to the need for major dredging on the St. Lawrence River, to extend the navigation season on the St. Lawrence River to 11 months, has not been completely resolved (i.e., engineering feasibility has not been determined). In addition, significant objection has been raised by the U.S. Fish and Wildlife Service, State of New York, and local residents to the potential impacts of any major dredging to enable 11 month navigation on this portion of the system.

(4) Should dredging be considered necessary, the economic incremental justification as to maximization of net project benefits is still somewhat speculative due to the uncertainty as to the type and extent of dredging required. As can be seen on Table 2 of the Main Report, an extension of the navigation season from 10 months to 11 months on Lake Ontario and the International Section of the St. Lawrence River may or may not be incrementally justified based on the current preliminary minimum and maximum quantity estimates of possible dredging that may be used.

(5) A 10-month season allows for more deliberate lock maintenance.

(6) An eventual 10-month season may tend to strike a balance between environmental and economic interests.

Because of its seeming importance on the St. Lawrence River, several factors must be considered relating to the necessity for dredging, and the magnitude of dredging required, to provide for extended season navigation, particularly in the reach between Chimney Point (Ogdensburg, NY) and the downstream end of Ogden Island.

A primary concern is the maintenance of a stable ice field. If this is not accomplished, loose ice could contribute to the formation of ice jams. This would increase ice retardation, defined as the reduction of the flow of a river due to ice cover. Ice retardation can also be accentuated by increased ice roughness and/or thickness.

The formation of ice jams and increased ice retardation could result in: (a) impeding commercial navigation; (b) a decrease in water levels below Low Water Datum downstream of the ice jam; (c) reduction in the flow to the extent that reductions in hydroelectric power generation result; and (d) possible upstream flooding.

There are several options that can be evaluated in overcoming these difficulties. The alternatives include:

(1) Reducing the regulated outflow of the St. Lawrence River coupled with the necessary regulation changes in the downstream (Canadian only) portion of the river;

(2) Dredging, for the purpose of reducing flow velocities to promote a stable ice cover and installation of additional ice control structures and the temporary control or cessation of vessel movement to allow for the initial development of a stable ice cover; and,

(3) Annual installation of ice control structures combined with the cessation of vessel traffic during the ice formation period, without dredging.

Solutions must incorporate allowances for the development and maintenance of a stable ice cover. In the St. Lawrence River reach between Chimney Point and the downstream end of Ogden Island, the existing average river flow velocities range from 1.0 fps to 3.5 fps at a river flow of 220,000 cubic feet per second (the flow during the ice formation period). Ice booms would be installed in this reach to control the movement of ice, to promote a smoother, thinner ice cover and thus increase the flow capacity of the river. However, due to the existing velocities in this reach, utilizing a series of ice control structures, independent of other improvements, may not provide satisfactory results for an 11-month navigation season.

The reduction in regulated outflows alternative primarily addresses increased draft needed upstream of the control structures to accommodate navigation. If this alternative were implemented, it would involve the redistribution, over time, of water available for hydroelectric power and would require additional dredging for maintenance of vessel draft in Canadian waters. Since Canadian co-participation has not been agreed to, so far in this study, the alternative cannot be fully evaluated at this time. This alternative could be addressed during the advanced engineering and design phase, which would include Canadian co-participation.

The annual installation of a series of ice control structures in the International Rapids reach in combination with a cessation of vessel traffic during the ice formation period (early January to early February) should provide a satisfactory solution to the problem of 10-month extended navigation in this reach. To assure the proposed control structures would function as intended, a combination of mathematical and physical models would be developed and constructed. This would be coupled with a vessel transit test of the system of structures during the advanced engineering and design phase of project implementation.

Due to the velocities which currently exist in this reach, a series of ice control structures, alone, may not provide satisfactory results for an 11-month navigation season. Therefore, for an 11-month navigation season, it may be necessary to dredge approximately 25.2 million cubic yards of material from various portions of this reach in order to reduce the average river flow velocity to 2.25 fps. This reduced velocity, in conjunction with ice control structures, would, given proper weather conditions, allow a greater opportunity for a stable ice cover to develop and remain during ship passage.

IMPACT ASSESSMENT

Economic Justification - Recommended Plan

In order to accurately determine the economic feasibility of the recommended plan to extend the navigation season 12 months on the upper four Great Lakes and 10 months on the Welland Canal-Lake Ontario-St. Lawrence River portion of the system, it is necessary to subtract out the benefits contained in the March 1976 Interim Feasibility Study to extend the navigation season to 31 January on the upper four Great Lakes from the total benefits associated with the recommended plan (as shown in Table B-5). This prevents double-counting of benefits and assures that only those incremental benefits that are in excess of those contained in the March 1976 Interim Feasibility Study are allocated to the recommended plan. The latest average annual benefits associated with the March 1976 study are as follows (for a more detailed description of both the benefits and costs of this Interim Study see Table 40 of Appendix D):

Transportation Rate Savings	$ 0
Winter Rate Savings	4,982,000
Stockpiling Savings	5,471,000
TOTAL	$10,453,000

TABLE B-5

TOTAL ANNUAL U.S. BENEFITS FROM RECOMMENDED PLAN (PROPOSAL 5) TO EXTEND NAVIGATION SEASON
(In $1,000 at 7-1/8%, and in 1,000 Tons)

Tonnage Benefited	1987	1990 1/	1992	1995 2/	2000	2040	Average Annual Benefits
Tons Div. Fr. Alt. Mode	4,721	8,546	10,554	16,209	27,173	47,164	24,248
Tons Ben. by Winter Rates	67,476	177,104	132,350	185,902	188,399	214,185	186,944
Tons Saved from Stockpile, Lock	4,126	10,524	20,647	21,706	21,735	22,179	18,726
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,009	3,201	3,521	7,085	3,307
Benefits							
Transp. Rate Savings	14,174	66,398	93,832	132,452	183,958	333,296	175,022
Winter Rate Savings	5,400	5,947	6,271	6,656	7,392	10,642	7,405
Stockpiling Savings	5,174	12,634	24,859	26,356	26,719	30,864	23,239
Total Benefits	24,748	84,979	124,962	165,464	218,069	374,802	205,666

1/ 1990 is the estimated start of year-round navigation on all of the upper four Great Lakes.

2/ Estimated start of 10-month navigation on the St. Lawrence River.

3/ This average annual benefit figure does not include the following savings which could be realized under the 31 January ± 2 weeks plan contained in the March 1976 Interim Report: Also, $27.4 million of transportation rate savings resulting from the operational plan recommended in the March 1976 report are not tabulated as part of subsequent season extension proposals.

Winter Rate Savings	$ 4,982
Stockpiling Savings	5,471
Total	$10,453

The above average annual benefits associated with the March 1976 Interim Feasibility Study have been substracted from the total benefits of each of the proposals to extend the navigation season.

Harbors Included in Recommended Plan

In the GL/SLS economic region, cargo flows to and from Bureau of Economic Analysis (BEA) areas located in the 19 States of this region. For origin or destination from BEA's away from the Lakes, no indication is given as to what Lakeside BEA or port the cargo is shipped through. Traffic that has an origin or destination within a Lakeside BEA can be assumed to usually move to an alternative coastal port or ports within the BEA. However, BEA's frequently contain more than one port.

To overcome the difficulty as to what ports commodities flow through a port/split methodology was develop. A detailed description of this port/split methodology was utilized to derive normal season and extended season traffic projections for those major Great Lakes harbors expected to benefit from the recommended plan.

A summary of the total estimated stockpiling, transportation rate, and winter rate benefits, the annual costs, and the ratio of benefits to costs for each of the major Great Lakes harbors having traffic benefiting from the recommended plan to extend the navigation season, are shown in Table B-6. Only those benefits are displayed in Table B-6 which are in excess of those benefits associated with the March 1976 Interim Feasibility Study.

In order to determine what percent of system costs (improvements that are not in a specific harbor, but are on the Great Lakes, the St. Lawrence River, or the connecting channels and locks) should be allocated to each of the major harbors, the total annual benefits accruing to each harbor were examined to determine whether they originated from season extension on the upper four Lakes alone or from extension on the entire GL/SLS System. A harbor should only share in the cost allocation for those system improvements from which it benefits. For example, if a harbor does not

TABLE B-6

AVERAGE ANNUAL BENEFITS AND COSTS
FOR U.S. HARBORS IN RECOMMENDED PLAN
(in $1,000 at 7-1/8%)

	Harbor Annual Benefits	Harbor Annual Costs	Benefit/Cost Ratio
Two Harbors, MN	$ 5,488	$ 1,678	3.3
Duluth-Superior, MN-WI	52,426	14,263	3.7
Presque Isle, MI	1,703	516	3.3
Marquette, MI	159	192	0.8
Taconite, MN	5,640	1,723	3.3
Silver Bay, MN	5,623	1,744	3.2
Ashland, WI	250	668	0.4
Green Bay, WI	478	373	1.3
Milwaukee, WI	2,997	323	9.3
Calumet Hrbr., IN-IL	13,917	1,841	7.6
Indiana Harbor, IN	6,888	1,200	5.7
Burns Waterway, IN	1,925	461	4.2
Gary, IN	3,888	689	5.6
Escanaba, MI	2,822	1,571	1.8
Ludington, MI	6	401	0.0
Port Washington, WI	426	131	3.3
Saginaw, MI	10	539	0.0
St. Clair River, MI	1,562	477	3.3
Detroit, MI	25,641	3,425	7.5
Alpena, MI	44	290	0.2
Toledo, OH	9,002	2,011	4.5
Sandusky, OH	1,124	729	1.5
Huron, OH	3,826	1,407	2.7
Lorain, OH	5,198	1,791	2.9
Cleveland, OH	23,362	3,893	6.0
Ashtabula, OH	3,959	1,478	2.7
Conneaut, OH	6,763	2,274	3.0
Buffalo, NY	19,025	4,850	3.9
Monroe, MI	1,451	717	2.0
Muskegon, MI	56	405	0.2
TOTAL SYSTEM BENEFITS	$205,666	$52,061	4.0

benefit from season extension on the St. Lawrence River, then the cost of the system improvements on the St. Lawrence River, should not be allocated to it. The annual system costs allocated to harbors were added to the annual costs of improvements in the individual harbors themselves to derive total annual harbor costs for the recommended plan.

Only those harbors with a benefit/cost ratio of greater than 1.0 are economically justified. The following paragraph depicts what the impact on the overall benefit/cost ratio of the recommended plan would be if these economically unjustifiable harbors were excluded.

Benefit/Cost Ratio of Recommended Plan - Excluding Harbors Unjustified from a Federal Investment Viewpoint

If only those 25 harbors with a benefit/cost ratio greater than 1.0 (as shown in Table B-5) are included in the recommended plan, then the overall annual benefits of the plan decrease from $205,666,000 to $205,131,000, and the overall annual costs decrease from $52,061,000 to $49,718,000. Therefore, the net effect on the benefit/cost ratio of the plan from the exclusion of these harbors is to increase the B/C ratio from 4.0 to 4.1. It should be noted that the decrease in benefits that results from the exclusion of these currently unjustified harbors stems from two factors: (a) the elimination of the benefits accruing to the economically unjustified harbors themselves, and (b) the elimination of the benefits accruing to those harbors that trade with the economically unjustified harbors. It is also important to note that the reapportionment of annual benefits and costs to the 25 remaining harbors does not result in any additional harbors becoming economically unjustified.

Possible Negative Benefits

Concerns expressed regarding possible negative benefits of season extension on (1) the environment (such as changes in fish and wildlife habitat/population and aesthetic values) and on (2) winter recreational use of lakes, harbors, and channels have not yet been fully quantified. They are not included in the current benefit/cost ratio of the recommended plan. The benefit/cost ratio does include the estimated amount for the Environmental Plan of Action (EPOA) and a winter recreation study, both of which are to be initiated in the advanced engineering and design phase. Implementation of these studies would provide information as to the quantification of any environmental/recreational disbenefits associated with the

recommended program. To date, no disbenefits have been identified which would substantially alter the benefit/cost ratio. However, as environmental/recreational disbenefits become quantified during the pre-construction planning and advanced engineering and design phases, the dollar amount will be included in the benefit/cost ratio and displayed in appropriate EIS's.

Secondary Regional Impacts

Appendix D contains the results of the Regional Economic Benefits Study conducted for the Corps of Engineers by Booz, Allen and Hamilton, to determine the regional impact of navigation season extension on the Great Lakes Region. This study depicts the regional benefits and employment accruing directly to individual Great Lakes ports, as well as the regional economies surrounding these ports. It is essential to note that these regional benefits represent regional transfers of income to the Great Lakes Region from other regions of the country, based on that traffic which would be diverted to the GL/SLS from other transportation modes as a result of season extension. As such, these regional benefits are not included in the recommended plan's overall benefit/cost ratio, which only addresses net increases in the nation's overall efficiency in the transportation of goods (as reflected in the project's primary, transportation-related benefits).

As mentioned above, navigation season extension will tend to divert future expected traffic away from the rail and trucking industries and Eastern and Gulf ports toward the GL/SLS System. In order to determine what impact this diverted tonnage would have on the various transport modes and regions concerned, an Intermodal Impact Study was undertaken and is described in Appendix D. Again, it should be noted that any regional disbenefits would represent a

regional transfer of income away from other transport modes and regions of the country to the Great Lakes Region and, as such, would not be included in the recommended plan's overall benefit/cost ratio.

Energy Impacts

Appendix D contains the results of the Energy Impact Study undertaken for the Corps of Engineers by TERA, Inc., to determine the effect that navigation season extension would have on energy consumption. Specifically, this study compared the energy consumption associated with winter waterborne movement of bulk and general cargo during an extended navigation season to the energy consumption associated with winter movement of the same commodities via the least-cost alternative transport mode (rail, truck, barge). Energy impact results were based on severe winter conditions. Included in the analysis were the increased transit times and delays that would be associated with winter navigation operation for the various size vessels in the Great Lakes and overseas fleets, as well as the energy expended by the facilities and operations (the infrastructure) required to support winter navigation. The study concludes that there would be a small, but positive, energy impact associated with the increased GL/SLS waterborne movement that would result from an extended navigation season.

Power Production

As far as the impact of winter navigation on power production is concerned, the expected ice condition with the proposed plan of improvement in operation is expected to maintain normal water levels and flows, therefore, there would be little to no impact on power on the upper lakes. The ice control proposed for the St. Lawrence River should eliminate the severe ice dam problem in that river and should provide a benefit to power through increased head and the maintenance of outflow capability.

Environmental

Although the environmental concerns of an extended navigation season are numerous and varied, few potential impacts have been documented. Such impacts as have been identified can be found in Appendix F, Environmental, where they are discussed and evaluated specifically in relation to conditions that were found to exist during the Navigation Season Extension Demonstration Program.

A summary of concerns that have been expressed are listed below These concerns are listed in no particular order since each could be a required component of the total study effort. When completed, the appropriate studies mentioned should provide the information required to suitably evaluate the impacts of an extended season on the Great Lakes-St. Lawrence Seaway System.

Air Quality

The implementation of the recommended navigation season extension plan could temporarily alter the pattern of atmospheric loading on a local basis. As vessel traffic expands and the work effort is increased, as would be experienced by navigation through ice, levels and distribution of emissions to the atmosphere could be affected. With extended season shipping, any air quality improvement that may have been associated with a non-shipping winter season could be altered, if not eliminated. Construction, dredging, and equipment operation as proposed for the project could adversely influence local air quality.

Impacts on Noise

Activities associated with winter navigation which could have possible impacts on noise levels include construction operations,

dredging and its related disposal activities, icebreaking and commercial vessel operations. Noise associated with construction operations would be temporary in nature, while other activities may have a longer duration of increased noise levels. The effects of these noise levels are hard to determine due to the fact that overall noise problems are complex since they depend on distance, wind, weather, and the particular listener. While it is possible to identify and quantify sounds attributable to various operations, it is difficult to predict the subjective interpretation in a given location under varying conditions. Impacts are expected to be of a low nature due to the reasons stated above. However, many permanent residents of connecting channel areas may be irritated by the change.

Impact on Water Resources

The water resources of the Great Lakes System would, to varying degrees, be affected by activities proposed under the extended navigation season program. Such activities include: dredging, dredge material disposal in open water, winter navigation/icebreaking, construction of shore erosion and shore protection measures, the installation or modification of ice booms and navigational aids, and the construction and operation of water compensating works. Long term effects would be those resulting from increased sedimentation from ship passage and those resulting from erosion due to ice movement at shorelines.

Water Quality

With the possibility of additional dredging and disposal operations, temporary increases of localized turbidity would occur. This turbidity could restrict biological productivity in a number of ways; however, the two most significant with respect to water quality

are the restriction of light availability to photosynthetic organisms and aquatic flora and the possible resuspension of incompletely digested benthic material. Also, dredging and vessel maneuvering could cause resuspension of heavy metals and toxic substances, which would lower water quality.

Before a concise environmental evaluation to supplement that already accomplished for all dredging activities can be made on the specific effects on water quality from the recommended plan, additional information is considered necessary. Areas of studies that are proposed include: (a) site-specific water resource base condition studies, where data gaps exist; (b) studies on the combined effects of vessel movement and bubbler system operations; (c) monitoring and validation of perceived impact studies related to vessel operations in an ice environment, including icebreaking activities; and (d) effect of vessel passage on shore erosion.

Further information on water resources studies being proposed or currently conducted is contained in Appendix I, Levels and Flows, and Appendix E, the Environmental Plan of Action.

Impact on Energy

In order to determine the energy impact of extending the navigation season on the Great Lakes/St. Lawrence Seaway (GL/SLS), an Energy Impact Study was undertaken for the Corps of Engineers by a consulting firm - TERA, Inc. Specifically, this study compared the energy consumption associated with winter waterborne movement of bulk and general cargo during an extended navigation season to the energy consumption associated with winter movement of the same commodities via the least-cost alternative transport mode (rail, truck, barge). All line haul movements were specified as origin to destination movements shipped either via a GL/SLS routing or an alternative

transport mode routing. The analysis measured the change that extended season navigation would have on the energy consumed in line haul freight operations as a result of: (1) traffic being diverted to the GL/SLS system from alternative transport modes, and (2) Great Lakes traffic being redistributed from the normal season to the winter season as a result of altered stockpiling patterns. For greater detail on this energy impact study see Appendix D. The study concludes that there would be a small, but positive, energy impact associated with an extended navigation season.

Impact on Sediment Transport and Shore Erosion

Actions which could cause sediment transport and shore erosion include the direct movement of ice in contact with vessels, propeller wash, drawdown and surge, dredging, and construction of structures (ice booms, etc.). The significance of these various factors depends on a number of local conditions such as the water depth and bottom configuration, water levels, soil conditions, ice conditions, and the presence of other transport agents (e.g., natural currents or waves).

Other Effects

There may be effects beyond shoreline erosion. Large areas of grounded ice resulting from the packing of brash ice under the ice cover or increased frazil production due to increased open water areas have also been proposed as a possible medium for the transmission of ship-induced vibrations to the shore and shore processes. These vibrations have been reported to range from aesthetically disturbing to structurally damaging.

Disruption of an ice cover may also have some as yet undefined effect on ice movement and damage by natural forces. In the case of relatively ice-free rivers such as the Detroit-St. Clair Rivers, the

disruption of an ice cover on the lakes upstream may allow large quantities of ice to pass through. This in some cases has been observed to cause bottom scour and ice piling at bends and the upstream ends of islands. The large forces possible from ice runs could also pose a special threat to shore protection measures.

In most coastal areas natural shoreline modification forces such as waves and currents would be far more significant than any vessel related effects, and in most cases the shipping lanes do not come near enough to the shore for vessels to have a noticeable effect. In some more protected areas that may not be true. Ice movement problems after disruption could be particularly important in coastal areas with significant wind driven ice push.

Studies being recommended for evaluation of the effects of winter navigation on shore erosion and sediment transport are presented in Appendix E.

Impact on Benthic Communities

Activities which could affect benthic communities (communities of organisms attached or resting on the bottom or living in bottom sediments of a river or lake) are: dredging, vessel operations, including icebreaking, bubblers, construction of shore protection measures and the installation of ice booms and navigation aids.

The most pronounced effect that the above stated activities have had individually or in combination with other activities, is the removal/disruption and suspension of bottom sediments, including benthic (bottom dwelling) organisms. Impacts have occurred in critical reaches of connecting channels, harbors and in shallow offshore areas, during both the extended season Demonstration Program and during customary season operations.

Impacts on Vegetation

Significant impacts of the recommended plan on vegetation appear unlikely over large areas of the Great Lakes System, but some especially perceived impacts could occur within constricted areas of the system, such as in connecting channels. Vessel movement could also disrupt shoreline, littoral zone, and wetland vegetation. Changes in ice cover due to icebreaking and vessel movement could affect the primary productivity on a localized basis.

On the positive side, decreasing ice thickness by bubblers or opening of channels by icebreaking and vessel movement would allow more light to penetrate into the body of water. On the other hand, construction operations could remove or adversely impact submerged vegetation. Dredging operations could eliminate areas of submerged growth.

Terrestrial

Construction of shore based aids to navigation, e.g., course ranges, would have a minimal effect on terrestrial vegetation. Beneficial and adverse impacts that could occur would be dependent upon site location. If the site consists of wooded vegetation, course ranges would be cleared of obstructive vegetation from the water edge to the rear of the range lights. The course ranges should not exceed 100 yards. Construction of required support facilities and required disposal sites for dredge material could cause loss of vegetation through removal or burial of flora, and habitat change.

Impact on the Fisheries Resource

The fisheries resource of the Great Lakes System could locally be affected through various program activities. The program activities in areas such as connecting channels, harbors, and shallow water

areas of lakes could influence fish spawning including egg survival, behavior, distribution, and habitats.

Potential changes in fish habitats could occur from a variety of project-related activities, which include vessel operations, propeller wash, addition of riprap, dredging, dredge material disposal, construction of navigation aids, compensating works, and icebreaking.

Impact on Wildlife Resources

Wildlife within the Great Lakes Basin could be impacted by the Navigation Season Extension Program. These impacts would occur in the coastline area where the project-related activities occur. As previously mentioned, the areas of major perceived impact are the shoals, littoral zones, and coastal wetlands of connecting channels and harbors. These areas are valuable for wildlife movement and migration, breeding, and habitats.

Migration of mammals that use ice cover for crossing water barriers could be affected under the program.

Wildlife breeding could be affected by the program through the loss of breeding habitat. Construction activities, dredging, and vessel operation could eliminate, degrade or enhance the breeding value of certain areas. Of main concern are emergent wetlands that could be impacted by the above activities.

A variety of waterfowl and shorebirds, as well as mammals such as muskrats, raccoons, and mink, utilize these areas for feeding, resting, and migration. Loss of these important habitats due to physical alteration or removal by the project activities could lead to decreased production. This could, in turn, affect the ecology and economics of nearby areas by decreasing the number of organisms present which could reduce trapper catches.

Open water may be created or modified by icebreaking activity associated with the program, which includes U.S.C.G. icebreaking activities and/or commercial vessel traffic in an ice environment.

It has been reported by the Michigan Department of Natural Resources (MDNR) that the winter feeding areas created within ice packs by warm water discharges have, at times, become severely restricted or reduced in size, due to efforts to extend winter vessel traffic. Vessel traffic, as reported by MDNR, could aggravate ice conditions by breaking the static ice packs and cause continual encroachment of ice packs into the winter feeding areas, thereby reducing the available feeding area. It is this restriction to waterfowl usage that, over a period of time, could cause malnutrition in waterfowl.

Upland habitats could be affected through construction activities of shore facilities and land-based navigation aids which could alter or eliminate small shoreline areas. These changes could cause the displacement of some fauna to neighboring areas.

Certain sensitive habitats in the Great Lakes Basin could be impacted more than others. Areas that may be of particular concern for endangered or threatened species are the coastal wetlands.

The Environmental Plan of Action suggests that a system-wide study be conducted on endangered and threatened species and their critical habitat. Existing data would be compiled and additional field work performed. Further investigation would take place where recommended activities may require an environmental document, in accordance with Section 7 of the Endangered Species Act of 1973, as amended.

The validity of any conclusions drawn from the potential studies set forth above, would be limited to the extent that any information gathered and analyzed would be representative of the interaction of an extension of the navigation season and the environment. However, the environmental baseline data that is collected may be useful for other system-wide studies other than winter navigation. The Environmental Plan of Action and subsequent 10/15 year monitoring and evaluation period would ultimately allow determination of the total environmental feasibility of a phased extension of the navigation season on the Great Lakes-St. Lawrence Seaway System to as much as 12 months, or year-round.

Social Well-Being

Concerns have been expressed at public meetings regarding potential damages to shore and shore structures due to vessels operating in constricted areas of connecting channels and ice; potential hazard to public safety, health, and welfare of crew members and personnel required to cross channels on ferry boats; the potential disruption of outdoor recreation activities such as ice fishing and snowmobiling; other potential adverse environmental impacts on vessel crews such as the ship induced noise and vibration; and potential disruption of power generating facilities due to ice jams. Additionally, a review of all previously identified social effects and a projection of a range of potential future effects was made. Appendix H indicates that social effects were identified in four major categories: recreation, shore erosion and structure damage, cross channel transportation, and occupational groups (see Appendix H).

a. Winter Recreation

Effects of winter navigation upon winter recreation occur when icebreaking activities within the channel make the adjacent ice cover potentially unsafe for on-ice activities. Recreational ice fishermen and snowmobilers are affected. Three studies have been completed to date which address the problem; however, as it turned out, all were conducted during mild winters. A study identified those harbor areas where winter navigation was likely to affect recreational activities, and recommended further studies of those areas. A second study surveyed winter recreationalists along the St. Marys River and less than one-half expressed negative opinions regarding winter navigation and recreation. A third study on the St. Lawrence River concluded that ice fishing was a major form of recreation for some people living close to the areas and, therefore, not a major economic stimulant to the area. It was concluded that in the St. Lawrence River area, the weakening of the ice cover from ice breaking would not affect embayments where most ice fishing takes place.

Recreation studies completed to date do not fully assess the present or potential economic impacts of season extension activities on winter recreation activities. In order to integrate the previous studies, and to further quantify the regional and community impact of the possible disruption of winter recreation activities located adjacent to proposed winter navigation sites, an additional recreation study is proposed during the post-authorization, pre-construction stage. This study would establish the magnitude of winter recreation near extended season routes based on the distance traveled to the site, the number of participants, the amount of money spent, and those affected economically by these activities.

b. Shore Erosion and Shore Structure Damage

The second type of winter navigation related effect is shore erosion and shore structure damage (primarily docks). This is caused primarily by the disruption of ice cover and shorefast ice by the passing ships. Primary locations where this effect could be increased by a navigation season extension include areas along the St. Marys, Detroit, St. Clair, and St. Lawrence Rivers. Shore erosion and shore structure damage is considered, by the public, to be at least partially caused by the winter navigation activities. Specific conclusions have been developed for this report which consider both structural and nonstructural solutions to the problem of shore erosion and shore structure damage.

Alternative Courses of Action have been formulated to provide riparian owners with relief from shore erosion and shore structure damage associated with the Great Lakes-St. Lawrence Seaway Navigation Season Extension Program.

Riparian owners have long and continually, according to results of recently documented studies, suffered accelerated shore erosion and aggravated shore structure damage due to the Great Lakes-St. Lawrence Seaway Navigation Season Extension Demonstration Program. In order to properly redress riparian owners and best accommodate this situation, several courses of action have been considered. These courses of action range from the Government's current exercise of its right of navigable servitude of all land and structures below the ordinary high water mark in navigable waters (in which responsibility on the part of the Government is very limited) to that of accepting full and complete responsibility for financing the repair and replacement of all structural damage and erosion. In addition, there are several intermediate, responsibility-sharing alternatives. It should be realized during this discussion that,

according to the doctrine of navigable servitude over all lands and structures below the ordinary high water mark in navigable waters, the Federal Government can only be held responsible for structural damage or loss of property occurring above this mark. Consequently--unless some new enabling legislation takes place--the Government is not liable for any damage resulting to property below the ordinary high water mark and, therefore, will not compensate the owner. (For further discussion of "Federal Navigation Servitude," see Appendix J, Legal Considerations.) A description and discussion of each of the considered courses of action follows.

First Course of Action - Government Assumes Full and Complete Responsibility: In this course of action, the Government would be responsible for financing the repair and replacement of all damaged structures and prevention of erosion resulting from the Extended Winter Navigation Program, both above and below the ordinary high water mark. This alternative could be implemented by the property owner submitting a claim to some agency such as the Corps of Engineers. The Government would then provide the necessary funds to the owner or to a contractor to restore the property or structure. The advantage of this alternative is that it may tend to eliminate the anticipated complaints of property owners who suffer structural damage or severe erosion. However, several disadvantages exist: it may be an extremely costly means of solving erosion and structural damage problems which may or may not be caused by Winter Navigation; the obligation to finance repair and replacement may reoccur each year; this course of action does not recognize governmental immunity; and finally, there may be insufficient incentive for riparian owners to take proper precautions to protect their property or structures.

Second Course of Action - Maintain Current Situation and Responsibilities: This is the extreme opposite of the first course of action. In this case, the Government exercises its navigable

servitude over all lands and structures below the ordinary high water mark and is liable only for structural damage or loss of property occurring above the ordinary high water mark. Compensable damage suffered above the ordinary high water mark could be handled in the same manner as suggested by the first course of action. Owners could submit a claim for cost of repair or for loss of land suffered to a government agency such as the Corps of Engineers. The Government would then proceed to pay the claim in the same manner as other claims are acted upon. The advantages of this course of action are threefold: the navigable servitude of the Government is recognized and eliminates the need to compensate for damage or loss below the ordinary high water mark; this is the minimum cost plan; and by compensating for damage or loss above the ordinary high water mark, the Government would be fulfilling its duty to pay for the taking of any land which occurs in the exercise of the Government's duties. Disadvantages of this alternative include the inevitable complaints by residents or riparian owners following their noncompensable losses. Recent studies substantiate that there is a loss below the ordinary high water mark that could be attributable to extended navigation. Additionally, the cost of repairing or compensating for damage or land lost above the high water mark could still be expensive and continuous, as damage would have to be corrected each year following the season extension period. Based upon public response received thus far, this course of action, as the ongoing situation, would be unsatisfactory to the riparian owners.

Third Course of Action - A One Time Erosion Claim Alternative Below High Water Mark: Presently, refusal to compensate for damages above the ordinary high water mark would be contrary to the Federal Tort Claim Act and the Fifth Amendment. In this course of action, the Government would, on a one-time basis, provide financial support to permanently repair, replace, and/or compensate for loss of land below the ordinary high water mark and refuse liability for all

future damages or erosion below the ordinary high water mark. No compensation would be made for structural damages in this alternative. In this course of action, notice would be given to all current owners, all future purchasers, and all those who seek to build below the ordinary high water mark that they would be doing so at their own risk. Proper notation might be made in the Register of Deeds Office as one means to make future purchasers aware. This course of action would be implemented by allowing present property owners to submit claims in the manner as suggested in previous alternatives. Community meetings and/or local publications would also be utilized to communicate the necessary caveat to those who seek to buy or build in the future. The advantages of this alternative include the fact that it seems fair to compensate present property owners for their damages even though compensation for some of the loss may have previously been denied by the Government as subject to the navigable servitude. Also, those who do not now own waterfront property or structures can avoid injury by determining not to buy or build or to do so only if proper structural protection is utilized. Additionally, any permits that are issued could state that builders or owners should take into consideration the effects of navigation in their construction and that they build at their own risk. The disadvantages of this alternative are that it might take large sums of taxpayers' money to pay for the damage or loss below the high water mark for which the Government is not currently liable. Since this course of action is beyond current authorities, appropriate legislation would have to be enacted.

Fourth Course of Action - One-Time Erosion and Structural Damage Compensation as the Government Can or Will Accept Below the Ordinary High Water Mark: Currently, refusal to compensate for damages above the ordinary high water mark would be contrary to the Federal Tort Claim Act and the Fifth Amendment. Under this course of action, the Government could compensate riparian owners for damage suffered or

soil lost on a one-time basis following a designated Extended Winter Navigation Season. This one-time compensation would provide for permanent repair or replacement of damages. Subsequently, both present owners and future buyers would be put on notice that expense of repair for further structural damage or erosion would be borne by the individual without Government assistance. All property owners would be encouraged to take adequate measures to protect their property during future winters. The advantages of this course of action include a reduction of Government cost by eliminating repetitive claims while, at the same time, providing fair relief for the land owners affected adversely by the new program. However, after the first year, residents will be forced to take steps to protect their property and, if a loss incurs in spite of their efforts, it would be at their own expense. Disadvantages of this course of action are that if the compensation for loss or damage below the ordinary high water mark is suggested, this would be contrary to current doctrine but could possibly be included in the project authorization. On the other hand, this course of action appears to strike a fair balance between the Government's desire to economize and the property owners' hope to have their losses mitigated.

Fifth Course of Action - Provision of Tax Incentives: The Government could provide a tax credit or tax deduction to all those riparian land owners that spent sums of money to either protect their land from erosion and/or to appropriately reinforce structures in the water to withstand additional stress resulting from the Winter Navigation Program. Publications such as the Corps of Engineers already puts out and/or local meetings sponsored by Government agencies could provide riparian owners with information about what the program could do to their property and the best means those owners can use to protect themselves against damage and loss. Property owners could use the documented costs to themselves for

shoring up their land or strengthening their structures as the guideline for appropriate tax credit or tax deduction to which they would be entitled. It should be noted that this does not change liability for damage and loss occurring above the ordinary high water mark (which remains with the Government). The advantages of this course of action are several. Rather than providing monetary relief for repetitive repairs that would occur in some courses of action, this incentive program would encourage riparian owners to deal effectively with a new Winter Navigation Program. The Winter Navigation Program, if authorized and successful, would most likely be permanent in nature, having a great impact on the national economy. Therefore, it would appear appropriate to cope with its effects. The tax incentive would spread the cost of the program among all citizens, which would seem fair, as all benefit from year-round navigation will also be spread to the national economy. The disadvantages of this course of action are that a tax credit or tax deduction may be unduly expensive. This course of action might be successfully coordinated with the fourth course of action described above. After the Government compensates for a one-time damage claim, the tax credit or tax deduction could encourage residents to expend the necessary funds to reinforce structures and land and to bear the expense for future damage which may occur in spite of precautions taken to secure property. As a further derivative, such tax credits could be designated to only apply to shore erosion, since all new structures being permitted in the waterway could contain a condition placing responsibility for damage on the permittee. This would further limit the cost to the Government.

Sixth Course of Action - Federal Insurance Program: The Government could sponsor a Federal Insurance Program similar to Flood Insurance Programs for the benefit of riparian residents. An appropriate study program could be utilized to determine which

property owners could suffer adversely. These owners would qualify for the insurance protection. The advantage of this proposal is that residents would have a relatively inexpensive means of protecting themselves against ice damage, especially since private insurance may be difficult to obtain. On the negative side, however, this proposal would not encourage property owners to take steps to protect themselves unless the availability of insurance is conditioned upon implementing designated precautions. Alternatively, all affected people might be able to obtain coverage, but those individuals who have taken special precautions could receive reduced rates. It is possible that this course of action could be successfully coordinated with either the fourth or fifth courses of action, or both.

These first six courses of action may be grouped as possible solutions which are compensatory in nature. The four courses of action that follow may be seen more in terms of being preventative measures. Course No. 7 offers preventative measures in the form of structural alternatives; Nos. 8-10 provide non-structural preventative options. They spell out actions which can be considered at any time, regardless of decisions taken with respect to the first six courses of action described.

<u>Seventh Course of Action - Federal Protection of High Risk Area</u>: Studies currently underway indicate that certain areas of the connecting channels may be subjected to erosion or structure damage, no matter what level of non-structural preventative measures

(see Courses of Action 8-10 which follow) are taken. Therefore, these areas may require Federally supported protection if winter navigation is to be implemented.

A number of alternative solutions were investigated to determine the best ways of alleviating shore erosion and structure damage. They include: 1) broken rock shore protection; 2) Gabion basket/blanket structures; 3) concrete/steel walls; and 4) artificial nourishment, or replacement of shore material. For the specific protection of structures, pile clusters or the development of removable structures may serve the purpose. Ultimate solutions in the various affected areas would depend on site specific characteristics.

Eighth Course of Action - Vessel Speed Regulation: Several agencies have studies underway that indicate that one of the most effective means of preventing shoreline erosion and shore structure damage is the regulation of vessel speeds. In most cases, vessel speed reductions would not be required, but adherence to existing speed limits would be more stringently enforced. The primary advantages may be the minimization of damages. The main disadvantage may be the increased cost of vessel speed monitoring which would be borne by the U.S. Coast Guard under existing mission authority.

Ninth Course of Action - Regulation of Vessel Movement Through Unstable Ice Fields: An effective means of preventing the substantial shoreline and bottom scour that may result from ice jams is to regulate vessel passage through unstable ice fields. Vessels would be temporarily halted during critical ice break-up periods when it appears imminent that severe damage would result if shipping continued. The primary advantage is the prevention of damage. The primary disadvantage is the cost of a temporary halt in navigation to shipping interests. The decision to temporarily halt or reinstitute navigation rests with the Operational Coast Guard Commander.

Tenth Course of Action - Vessel Route Regulation: Another effective means of preventing shoreline erosion or shore structure damage would be vessel route control. This would include both the determination and designation of the vessel route, where possible, that would ameliorate erosion and also the restriction of random alternate routes which would result in multiple tracks in the ice cover where only a single track could handle the vessel traffic and not result in transit delays. This is important in an area such as the western end of Lake Erie, where ships could unnecessarily disturb the ice cover if each vessel took an individual route to ports along the southern shore. The primary advantages are the elimination of undue disruption of ice cover, and better allocation of Coast Guard icebreaking resources. The primary disadvantage would be minor adjustments to vessels' traffic routes, based upon needs.

Discussion: The first alternative, total Government responsibility, would be extremely costly, contrary to current policy, and would well be considered too repetitive for the Government to implement. The second course of action, the current situation, has not--as evidenced by the public forums and meetings on the Season Extension Program accomplished throughout the system--met the needs of the local residents when there are acknowledged liabilities to riparians because of the Season Extension Program. The third course of action, a one-time compensation to permanently prevent erosion below the ordinary high water mark, has the advantage of potentially satisfying the needs that have been mounting because of the Demonstration Program. The main disadvantages include: the possible high cost of this alternative; it applies only to erosion; and it is contrary to current policy and doctrine. As already mentioned, the fourth course of action, a one-time compensation for permanent repair or replacement for as much damage below the ordinary high water mark as the Government may wish to accept while putting the land owners on notice that any future loss would be borne by

owners, may seem to strike a fair balance among alternatives. It also covers structural damages. It, however, has the same disadvantages as its predecessor. The fifth course of action, providing tax credit or deduction if implemented totally and alone, may well be costly and repetitive. However, if the fifth were combined with course of action four, a one-time compensation and the tax credit or tax deduction limited only to shore erosion (since it seems fair that once put on notice, riparians should be responsible for placing a suitable structure in the waterway that could withstand Season Extension activity) could provide a fair balance and yet overcome any disadvantages that a one-time compensation might not take care of. The sixth course of action, provision of insurance somewhat similar to Flood Insurance, could be utilized if appropriate legislation is passed. However, this type of effort might be difficult to administer. It would have similar disadvantages to those of the Flood Insurance Program. The seventh, eighth, ninth, and tenth alternatives offer very desirable effects at a relatively low cost. Consequently, this group of alternatives, directed toward preventative action, would probably be implemented concurrently with other selected alternatives.

Conclusions: Upon evaluation of various courses of action, it appears that a one-time compensation on the part of the Government, for erosion and structural damage below the ordinary high water mark, best balances the incompatible interests concerned. After permanent improvements (repair or replacement) for protection are made, riparian owners would then assume responsibility for any future losses that might be incurred (i.e., navigable servitude would then be invoked). The objective achieved by this possible course of action would be the reduction of Government cost by eliminating repetitive claims while, at the same time, providing fair relief for the land owners affected adversely by this program.

It should be noted that because of dominant servitude of the Government, the Government is not liable for any damage resulting to property below the ordinary high water mark and, therefore, no compensation can be given to riparian owners. New enabling legislation would be needed to change this current policy.

The Government cannot immunize itself from liability for damages caused above the ordinary high water mark, and this situation would continue.

The costs of a compensation scheme would be substantial, depending in part on a final analysis as to which specific shoreline areas are particularly sensitive to the effects of extended season operations.

The preventative measures that can be taken to reduce shore erosion are an important element in plans to minimize the negative effects of an extended navigation season. Federal protection of environmentally high-risk areas, vessel speed control, vessel route regulation, and the regulation of vessel movement through unstable ice fields are viable ways of sharing the responsibility for minimizing negative effects associated with shore erosion and shore structure damage.

c. Cross Channel Transportation

The third type of winter navigation related effect is interruption of cross channel transportation, which stems from ice clogging ferry docks and disrupting services, and from vessels causing a broken ice cover in channels which prevents cross channel transportation over the ice. Areas subject to ice clogging of the ferry docks are Sugar Island and--as claimed by residents--Drummond Island on the St. Marys and some ferry crossings along the St. Clair

River. Areas subject to vessel tracks disrupting foot travel or vehicle transportation are Lime Island's winter route, and Drummond Island's secondary winter route in the St. Marys River, as well as the area in and around Grindstone Island in the St. Lawrence River. Solutions proposed for the St. Marys River are suited to each island's particular situation. For Sugar Island, ice stabilization measures and an ice navigation boom, and the diversion of the sewage treatment outlet to the mainland dock are being recommended. The solution recommended for Lime Island is the continued operation of an airboat being recommended for one-time purchase at Federal expense under the March 1976 Interim Feasibility Report. At Drummond Island no modifications are recommended based on studies conducted during the Demonstration Program, however, further monitoring would be done and should there be impacts attributable to extended season operations identified, mitigation measures would be considered. At Grindstone Island in the St. Lawrence River, the provision of a tug with icebreaking capability is the recommended solution for maintaining access directly between the island and Clayton, New York. For each connecting channel where problems might occur, contingency plans have been or would be developed to assure transportation in emergencies and to provide reasonable means for handling delay situations. Even though, until the winter of 1978-79, no impact was claimed or predicted on St. Clair River ferries, legitimate impacts will be investigated and appropriate preventative or mitigative actions considered.

d. Occupational Groups

Four occupational groups (vessel, terminal, lock, and pilot personnel) have been identified as being directly affected by winter navigation activities. The effects on these groups are basically two types: individual safety and comfort, and the "psycho-social" effects of extended navigation season (morale, family relations, etc.). These effects occur on all vessels which operate throughout the system during the extended season, at all terminals receiving

extended season traffic, and at the Locks operating during the extended season period. A "sociological assessment survey" conducted by the Department of Commerce, Maritime Administration, contained recommendations concerning the improvement of cold weather clothing for affected personnel, use of volunteers for extended season operations whenever possible, a vessel monitoring and reporting system, and other improvements that would be equally suitable for winter or summer operation.

The potential and long-term social effects of winter navigation were identified through public meetings, interviews, and physical proximity to proposed winter navigation routes. These potential effects of winter navigation need to be monitored on a region-wide basis. A demographically based monitoring study utilizing the "social well-being account" methodology is proposed for the advanced engineering and design stage. The study would monitor selected areas throughout the region and document the gross social effects of extended season operations on various types of communities and occupational groups. The results of the monitoring program would be a part of future environmental statements and validation reports.

Risk

It should be recognized that some risks are associated with navigation season extension. Without full implementation of operational measures, the risk of ice jamming and subsequent flooding would increase. Icebreaking assistance, improved aids to navigation, air bubbler systems along constricted areas of navigation channels, ice control structures, and real time data collection and dissemination systems are examples of improvements which are designed to make operating easier in the system during the winter months and reduce the element of risk. Other risks, such as oil spills, crew safety, etc., are being analyzed, and measures are being recommended

to reduce such risks or reduce the potential damage. Areas already partially addressed are shipment of hazardous substances, crew and vessel safety, and vessel operating capabilities. Long-term risk to the ecosystem is being comprehensively addressed in the previously mentioned Environmental Plan of Action.

In June 1972, the Great Lakes and St. Lawrence Seaway Study of Insurance Rates was prepared by the Maritime Administration, U.S. Department of Commerce, in accordance with Section 107(c) of P.L. 91-611. This study detailed the physical risk, risk management and insurance costs attendant to an extension of the navigation season. The study also examined the factors that inhibit an extension of the season together with methods of countering these factors and legislative recommendations to implement a government program to provide marine insurance. The results of the 1972 report were updated in June 1979. The conclusions of this update indicate that insurance rates did not and would not inhibit season extension.

Levels and Flows

The Levels and Flows Study prepared for this report describes the hydraulic characteristics of the Great Lakes-St. Lawrence system with particular emphasis on ice formation, roughness and thickness and their effects on levels and flows. It includes a discussion of these conditions in relation to present conditions and the possible impact that changes in these conditions (as a result of movement of vessels through the ice) may have on the levels of the Great Lakes and flows in the Connecting Channels and St. Lawrence River.

It should be noted that the calculations presented in this report are not to be considered as a prediction of possible impacts but do show the extreme conditions for a hypothetical range of impacts.

Description of the Problem

The levels of the Great Lakes reflect the total supply of water to the lakes and that which flows out through their outlet channels. Since these channels are presently subject to blockage or retardation due to natural ice movement, anything which affects this natural process could, in turn, impact on the systems levels and flows. Since significant navigation historically ends by mid-December, extension of the season could have an effect on these ice formation and break up processes. The extended season could cause the ice to be rougher and/or thicker, thereby increasing retardation, or measures may be introduced to stabilize the ice cover, and thereby reduce or eliminate ice retardation. In either case, the effect of these changes must be evaluated and mitigative measures proposed where impacts are identified. The proposals in this report assume potential water level impacts and include compensating works in the St. Clair-Detroit Rivers.

Study Input

The basic data employed in this Levels and Flows Study are listed in Appendix I. The majority of the basic data originated from the 7 December 1973 Report of the International Great Lakes Levels Board to the International Joint Commission (IGLLB), which was extended through 1978 for use in this study. The hydraulic and hydrologic conditions for the system a. consistent with the relationship employed in the above study and those currently in use by the U.S. Army Corps of Engineers.

Approach to Determining Impacts

Since Lake Superior is regulated, the probable impacts on that lake and its outlet river, the St. Marys, were determined from an examination of the Demonstration Program which has existed on that system since 1972.

To analyze the effect of movement of vessels through the ice fields in the connecting channels and the St. Lawrence River, it was hypothesized that the carrying capacities of these channels (under ice conditions) would either be improved or be further hindered due to changes in ice conditions. To measure the theoretical maximum impact of this possible variance on the systems levels and flows, the historic ice retardation values for the St. Clair and Detroit Rivers were varied from total elimination of all ice effects (0% retardation) to that of doubling the effect (200% or twice that which was experienced). Although this range in effects was selected for the study, it is not to be implied that actual effects could ever reach these proportions. The results of these variations in ice retardations were converted to impacts on levels and flows by routing these changes in water supply through the system for the 1960-1978 period (the current 27 foot project depth for the Great Lakes-St. Lawrence River system).

Since Lake Ontario is regulated, maximum probable impacts were determined for possible changes in ice thickness and roughness on the St. Lawrence River.

Where possible impacts on levels and flows were identified, remedial measures have been developed.

Impacts and Mitigation Measures

Based upon actual observed conditions on the St. Marys River, and mathematical analyses performed during the Navigation Season Extension Demonstration Program, extension of the navigation season has been determined to have no appreciable impact on the levels and flows of Lake Superior or the St. Marys River.

The possible impacts on Lakes Michigan-Huron, Erie and Ontario resulting from extending the season to 12 months might hypothetically range from one extreme of total elimination of ice retardation on the St. Clair and Detroit Rivers to the other extreme of doubling the historical ice retardation on these rivers. Neither extreme is seen as realistic, and the truth lies somewhere between them.

The theoretical impacts in terms of changed water surface elevation in any one month, resulting from the elimination of all ice retardation on the St. Clair and Detroit Rivers, are shown below:

	Lake Superior	Lake Michigan-Huron	Lake Erie	Lake Ontario
Maximum Difference	0	-0.29 feet	+0.44 feet	-
Maximum	0	-0.16	0	0
Minimum	0	-0.22	0	+0.07 feet
Average	0	-0.18	+0.02	0

The theoretical impacts of doubling the ice retardation on the St. Clair and Detroit Rivers are shown below:

	Lake Superior	Lake Michigan-Huron	Lake Erie	Lake Ontario
Maximum Difference	0	+0.30 feet	-0.47 feet	-
Maximum	0	+0.17	0	0
Minimum	0	+0.22	0	-0.16 feet
Average	0	+0.18	-0.02	0

Impacts on the St. Clair and Detroit Rivers may occur because changes in the ice retardation on the St. Clair and Detroit Rivers could effect the natural discharge relationships which prevail. This could create changes in the water levels and outflows of Lakes Michigan-Huron and Erie. Changes in the outflow of Lake Erie due to a change in Lake Erie levels could result in impacts on the Lake Ontario water levels and outflows.

To restore the flows of the St. Clair and Detroit Rivers to what they would be, assuming total elimination of ice retardation, would require that a flow retarding structure be placed in each river. These structures, if necessary, would be located at Stag Island in the St. Clair River and at Peach Island in the Detroit River, and are described in the Proposed Plan Description section, with costs identified in the Design and Costs section of this report.

Mitigation for the impacts of above normal ice retardation on the St. Clair and Detroit Rivers has not been identified because, if the extended navigation season is contemplated, it has been proposed that ice control structures be placed at the head of both rivers. These structures would reduce the natural ice retardation by tending to hold floe ice and reducing the probability of ice jamming and flooding in these rivers and would, therefore, preclude the possibility of above normal ice retardation.

As noted above, consideration is being given to placing some form of ice control structures at the head of the St. Clair and Detroit Rivers. These structures would tend to reduce the natural ice retardation on these rivers and--depending on conclusion of ongoing studies--might require a remedial structure be placed in both the St. Clair and Detroit Rivers to offset the effects of the reduced ice retardation. The precise impacts of the ice control structures on the river ice retardation are not known at this time. However, a physical model is being developed which should be able to further define the actual impacts. These impacts would lie within the range identified for eliminating ice retardation and would be incorporated into the planning and design during the post-authorization stage.

The 10 month use of the Welland Canal could result in additional lockages occuring in the winter and could result in an ultimate lowering of Lake Erie by less than 0.1 foot. This impact could be offset with a reduction in the average monthly flow through the Welland Canal of approximately 100 cfs throughout the traditional navigation season.

As part of the examination of possible impacts of winter navigation on Lake Ontario and the St. Lawrence River, a theoretical computation was made to determine the impact of changes in river ice thickness and roughness and the occurrence of hanging ice dams. However, it should be noted that dredging and/or ice control in the St. Lawrence River could eliminate or greatly reduce these impacts.

For a 10-month navigation season, ice control structures could reduce changes in ice roughness and thickness in the St. Lawrence River as a result of winter navigation. Without these measures, a sensitivity analysis, which tested the theoretical impacts of changes in the St. Lawrence River ice roughness and thickness, showed that as the undercover of the St. Lawrence River ice became rougher, the ability to flow water through the ice covered channels is hampered and, therefore, the water level profile is lowered. The results also showed that increasing the uniform river ice thickness from 12 inches to 24 inches and holding the Lake Ontario water level and the St. Lawrence River flow constant reduced the water level at Lake St. Lawrence by as much as 1.34 feet. However, it should be noted that limited model tests made in connection with the Demonstration Program indicated that winter navigation would not appreciably impact ice roughness. This is due to the small area affected by vessel transits when compared to the total ice surface.

Ice control could structures also reduce or eliminate the possibility of the occurrence of a hanging ice dam in the St. Lawrence River. The elimination of the hanging dam constriction is necessary to allow for navigation in that river. An evaluation of the theoretical impacts of an occurrence of a hanging ice dam without the proposed ice control changes showed a reduction in the Lake St. Lawrence water level by as much as 2.45 feet below what it would have been under normal river ice conditions.

Institutional

The detailed recommended plan presented at the conclusion of the planning process is to be capable of being implemented based on its institutional and technological feasibility. The purpose of this section is to discuss the structure and composition of a body to superintend and guide the effort to extend the navigation season on the Great Lakes-St. Lawrence Seaway.

Background: The Winter Navigation Board was established by a Memorandum of Understanding, dated 16 November 1971, entitled "Great Lakes and St. Lawrence Seaway Navigation Season Extension Demonstration Program". The U.S. Army Corps of Engineers, Maritime Administration, U.S. Coast Guard, St. Lawrence Seaway Development Corporation, National Oceanic and Atmospheric Administration, Environmental Protection Agency, Department of Interior, and Federal Power Commission agreed for the Board to superintend the activities of Section 107(b) of the 1970 River and Harbor Act (Public Law 91-611), which provides for the entities included on the Board to undertake a program to demonstrate the practicability of extending the navigation season on the Great Lakes and St. Lawrence Seaway. The Winter Navigation Board has functioned, since its inception, to accomplish its charge, as given by the Congress. Additionally, the Board has provided advice and guidance to the U.S. Army Corps of Engineers in the accomplishment of this survey study as authorized by Section 107(a) of the same Act. Since the Charter and reason for existence of the Board expires with the conclusion of the demonstration program's authorizing legislation on 30 September 1979, some transition group, as a replacement for the Winter Navigation Board, would be desirable to continue to provide advice and guidance to the Corps of Engineers in pursuit of its survey program. More importantly, if and when enabling legislation is passed to proceed (at full scale or a reduced scale) with a Season Extension Program, some body--similar to the St. Lawrence River Joint Board of Engineers of Canada and United States which guided the construction in the 1950's of the St. Lawrence Seaway -- would be required to superintend and guide the planning, environmental investigations, design, construction, and possibly initial operation of the extended season program on the Great Lakes-St. Lawrence Seaway.

Need: In summary, if and when enabling legislation is passed to provide the means to extend the navigation season on the Great Lakes-St. Lawrence Seaway, a superintending body would be required to plan, coordinate, and accomplish the effort. This body could and should be established in any such enabling legislation. Additionally, since the Charter of the current Winter Navigation Board runs out 30 September 1979, a transition group is being established to provide advice and guidance to the Corps of Engineers and other Federal agencies as the Corps completes its survey effort so as to provide the coordinated input of the diverse groups which the current Winter Navigation Board embraces, and to provide guidance to Agencies performing its ongoing operation responsibilities.

Options: In looking at what options might be available to provide the superintendance and guidance of the season extension effort, one is quickly led to the success of the St. Lawrence River Joint Board of Engineers of Canada and United States which superintended the construction of the St. Lawrence Seaway during the 1950's. This Joint Board consisted of four members, two U.S. and two Canadian. The two members for the United States were the Secretary of the Army (whose alternate was the Deputy Chief of Engineers) and the Chairman of the Federal Power Commission. The U.S. portion of the Joint Board, as was the Canadian, was also served by a U.S. Section on-site, headed by a civilian engineer and such staff of civil engineers, hydraulic engineers, foundation engineers, and administrative personnel, as appropriate. In revie ing functioning and workings of the St. Lawrence Joint Board, it became apparent that some of its strengths were the relationship of its members to the needed interests at that time, the location of its members and alternate members within the Federal Capitals, so as to facilitate the coordination and decision-making, and--not the least--was the smallness of its size, two members only for each Nation.

These favorable characteristics of the St. Lawrence Joint Board are important to consider when presenting options for the composition of a joint board in the future to oversee extended season navigation. One option is to keep the number of members to something near the size of the successful St. Lawrence River Joint Board, remembering that Canadian participation needs to be allowed for (see Option One shown on Plate B-3). Other agencies and bodies which have participated on the present Winter Navigation Board would have important contributions to make as associates to the future board.

Associates would have specific responsibilities for advising the board in their respective areas of expertise. They would continue to participate fully in providing input on issues to be considered by the board.

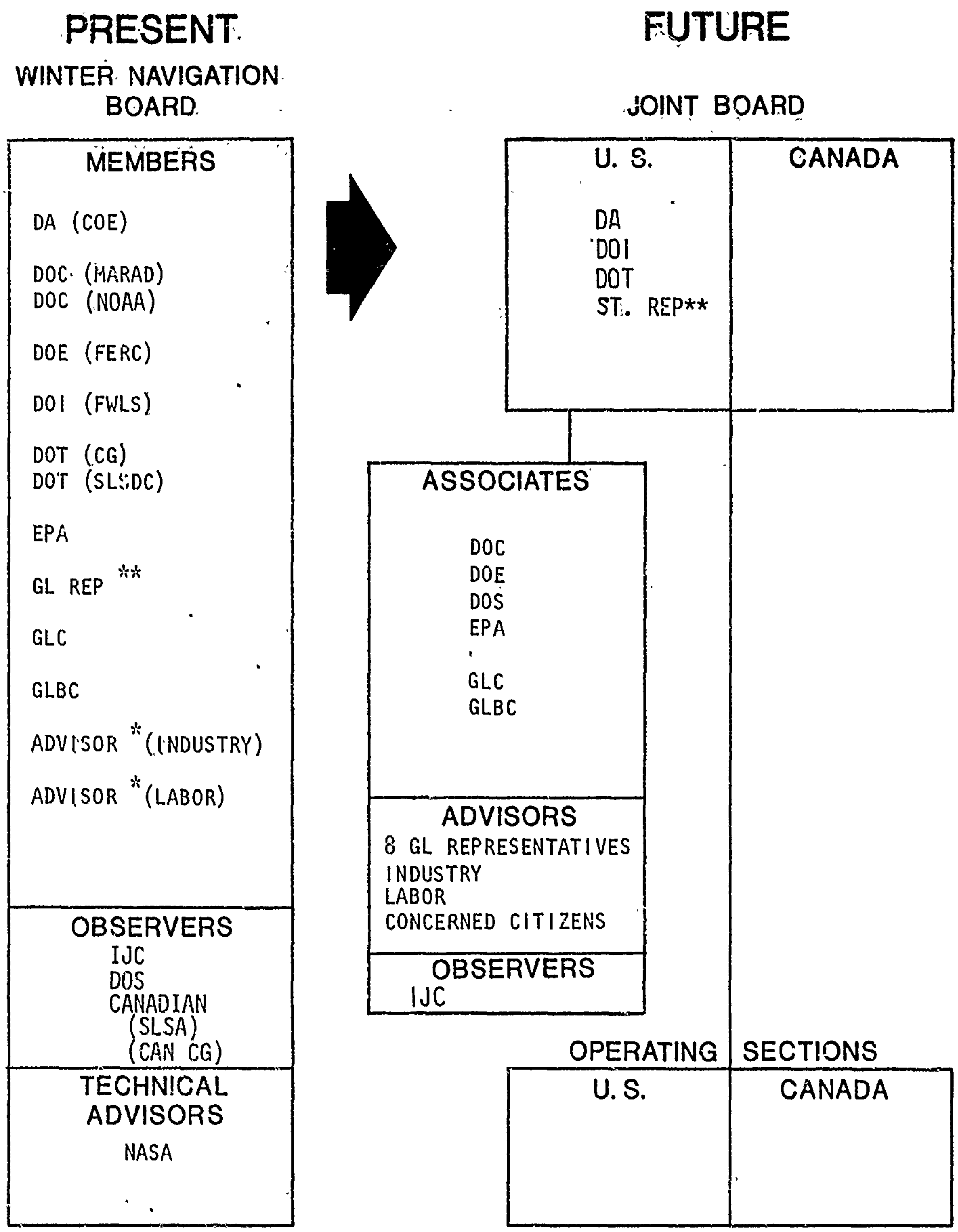
Options Two and Three, shown on Plates B-4 and B-5, respectively, increase the number of members on a future board (from four full-time U.S. members in Option One, to five in Option Two, to seven in Option Three), while the number of associates are correspondingly reduced.

In all three options, non-governmental entities, such as industry and labor representatives and private citizens would function as advisors to a future board. As these are the people and organizations most directly affected by extended season operations in the field, their direct involvement in the consideration of issues would continue to be essential.

Discussion:

a. Option One: Option One provides the smallest size U.S. Board that should be capable of reasonably quick action, has balance between transportation and environmental interests, and has the depth

JOINT BOARD OPTION NO. 1

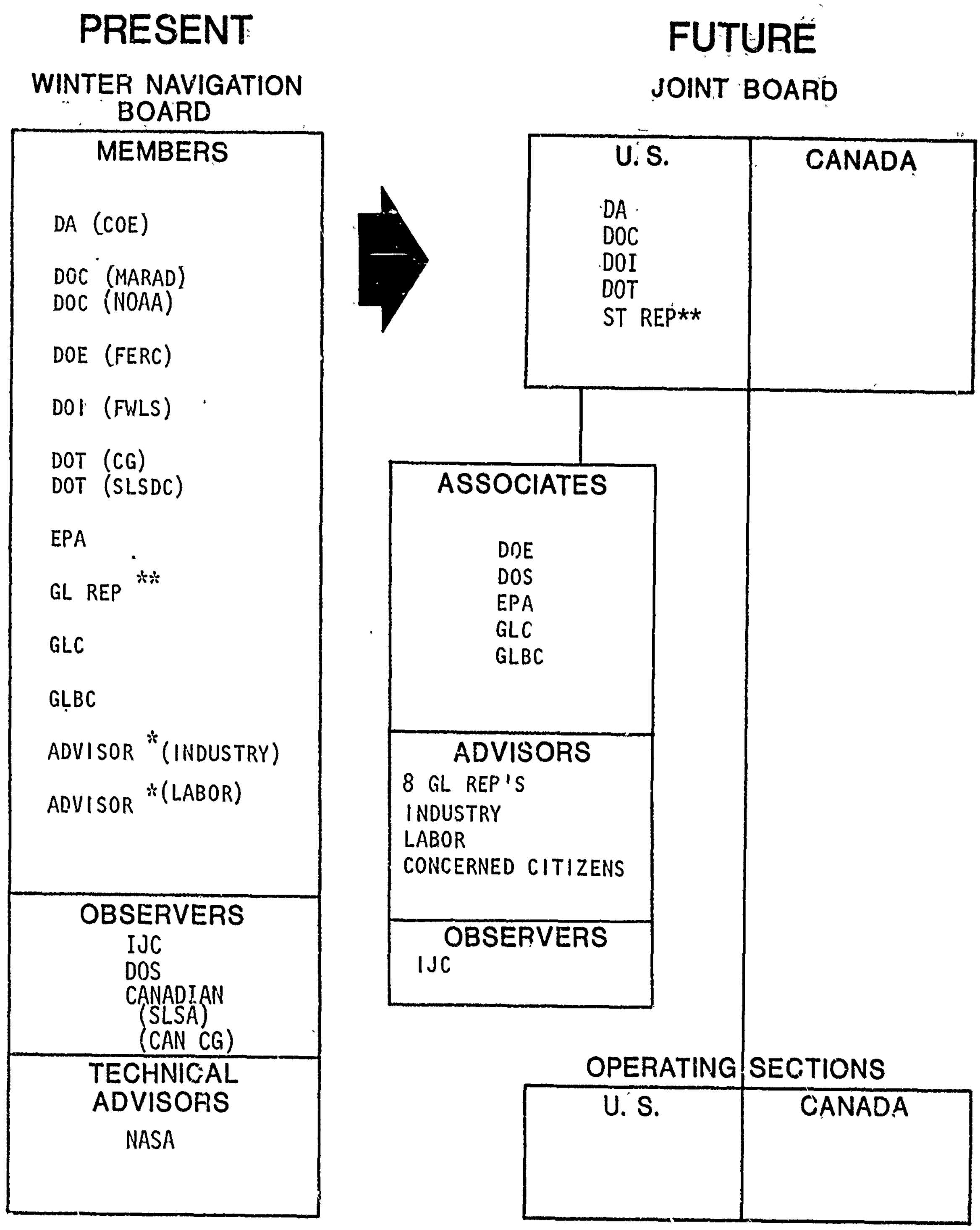


* APPOINTED BY ADVISORY GROUP

** REPRESENTS ALL GL STATES
FOR UPPER FOUR LAKES-MICHIGAN
FOR LAKE ONTARIO AND ST. LAWRENCE RIVER-NEW YORK

PLATE B-3

JOINT BOARD OPTION NO. 2



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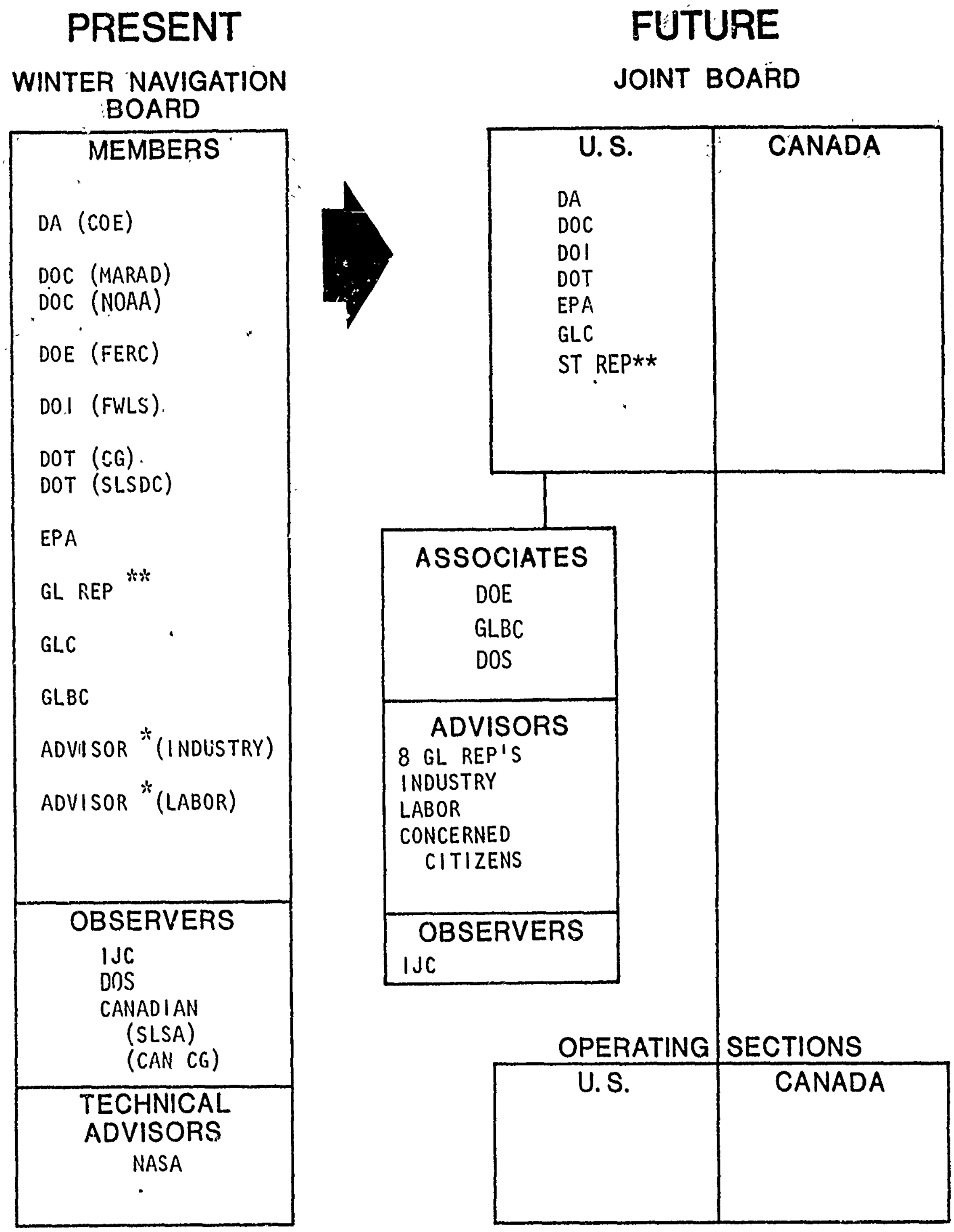
FOR LAKE ONTARIO AND ST. LAWRENCE RIVER-NEW YORK

PLATE B-4

JOINT BOARD OPTION NO. 3



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** REPRESENTS ALL GL STATES
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FOR LAKE ONTARIO AND ST. LAWRENCE RIVER-NEW YORK

PLATE B-5

and capability for receiving the views of the many diverse interests, via its associates, advisors, and observers. The grouping of agencies and groups into week-to-week acting members, associates, advisors, and observers in no way should inhibit the exchange of information and input of each of the groups into the Joint Board effort. In fact, each of the groups listed has a vital part to play in any successful accomplishment of a season extension program. One of the four permanent members to the U.S. section of the Joint Board under Option One would be a state representative. Specific requests have been made by the States of Michigan and New York to assure their representation on such a Board when matters under their jurisdiction come under consideration. It is proposed that a representative from Michigan serve in the capacity of state representative when matters concerning the upper four Great Lakes are to be considered by the Joint Board, and that a New York representative serve in this capacity when issues relating to Lake Ontario and the St. Lawrence River are discussed.

b. Option Two: Option Two includes a five-member, U.S. portion of the Joint Board and the additional interested agencies, groups, and persons as associates, advisors, and observers. The advantages and disadvantages of this option are similar to those of Option One, with this exception: the week-to-week acting membership includes a total of five. The advantages of this option over Option One are that a more diverse set of interests is represented in the week-to-week relationships. Conversely, the disadvantage is that a larger group of people need to be contacted on each and every minor decision concerning the program. Some might feel that the input by these members could well take place whether they were on the week-to-week effort or within the context of associates to the program.

c. Option Three: The Third Option, as diagrammed in Plate B-5, would reconstitute the U.S. portion of a future joint board with seven voting members. Most of the diverse interests now accommodated by the present Winter Navigation Board would have a full

representation in any of the ongoing activities that take place in the system. A drawback in enlarging formal participation to such an extent is the difficulty of effectively moving a program ahead when "decision-by-committee" procedures predominate. It is also possible that some members will be less interested in many topics than other members will be, with the result that the decision-making process may drag on without improving the quality of final decisions.

d. Additional Comments: These options provide a wide range of choices for any Joint Board and almost any intermediate selection could be made. The key criteria for establishing the Board should continue to be the ability to guide and superintend the program with reasonable speed of decision-making while providing for the access of important interests. Under any of the Options, all of the groups, be they associates, advisors, or observers, have an important role to play to provide their input into the decision-making process. Since it could be felt that all three Options provide the input and access needed, while Option One provides the best structure for timely decision-making and least cost to the governmental operation, this Option is most favored. Of course any solution would also make maximum use of the authorities already vested in the two seaway entities to make improvements.

e. Working Body or Section: Regardless of what the Joint Board looks like under Options One, Two or Three, it is anticipated some sort of operating section would be established on-site to handle the immediate and hour-to-hour functions of the Joint Board. Such an operating section might be organized as shown on Plate B-6, where one sees both the U.S. and Canadian operating section, each with a chief and staffed as required. During the 1950's, the operating section of the St. Lawrence River Joint Board of Engineers of Canada and United States was composed of a chief and up to six or seven additional personnel as the workload required. It is believed sections similar to these would need to be established to handle all the engineering and planning, and the environmental investigations and operations, as

JOINT BOARD OPERATING SECTIONS

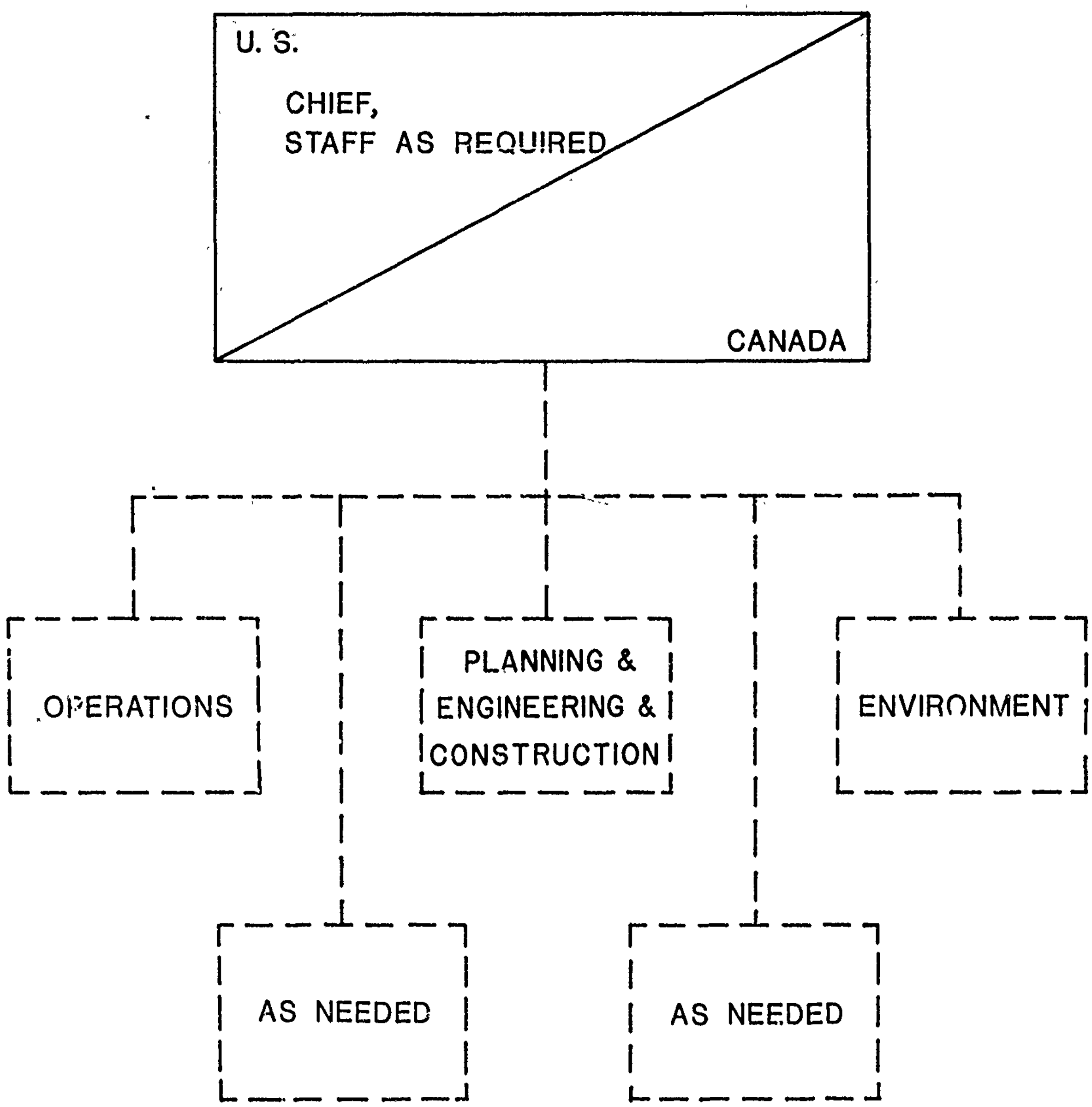


PLATE B-6

these surfaced. It is assumed that subsections established on an ad hoc basis, similar to those depicted in Plate B-6, would be required and could be established and curtailed as needed. Sometime during the life of the operating sections it is assumed, now, that there would have to be a construction and operations entity, an engineering and planning entity, and an environmental entity to accomplish the ongoing work of the Joint Board. The authorization for such operating sections is a necessity, but the detailed organization and sub-organization should be left to the Joint Board to provide the Board sufficient flexibility to best accomplish its mission.

Once transportation system improvements have been completed, and methods developed and proved in facilitating extended navigation season operations, a future U.S. section of the Joint Board would submit a final validation report on the program to Congress. At that time, it is expected that the Board would be disestablished, its mission of organizing and developing the program having been accomplished. Participating agencies could subsequently monitor extended season operations as a normal part of their operations.

Transition Group: The Winter Navigation Board in its final official meeting 6-7 August 1979, under the Charter of the Memorandum of Understanding, resolved that an Interim Winter Board be established and that it function under a memorandum of agreement of the principal responsible agencies at field operating activity level previously identified.

In this action, the Winter Navigation Board recognized a responsibility to the public and to private interests to provide a continuing forum for matters pertaining to extended season navigation on the Upper Four Great Lakes and a coordinating mechanism in the interest of supporting navigation and energy conservation needs and in addressing related social and environmental concerns.

Consistent with the apparent intent of the Congress, as indicated in an amendment to the Committee Print of HR4788, Section 121, the Winter Navigation Board also resolved that an Interagency Task Force be established to support the Interim Winter Board on matters relating to environmental and ecological effects.

The Winter Navigation Board further and finally resolved that all members and observers of the Winter Navigation Board be invited as observers to the operations of the Interim Winter Board and the supporting Interagency Task Force.

On 23 October 1979 an Interim Winter Board was formed based on a Memorandum of Understanding signed on that date by representatives of the U.S. Army Corps of Engineers, U.S. Coast Guard, a State Representative - Michigan, Great Lakes Commission, and representatives from Industry and Labor.

The Memorandum of Understanding stated that the purpose of the parties to the agreement, in the absence of other enabling legislation, and in accord with existing authority, was to establish an Interim Winter Board to coordinate winter navigation season closure determinations and potential agency programming actions, and provide a forum for keeping the public informed of winter navigation activities.

The term of the Memorandum of Understanding will continue in force for one year or until supplemented by Congressional resolution or legislation, whichever comes first.

Coastal Zone Management

The Great Lakes Coastal Zone is defined by lakeward and landward boundaries. By Federal definition, lakeward coastal area includes all submerged lands, waters and islands of the Great Lakes and connecting waterways, to the State or International boundary in the lakes or channels. The landward coastal area extends inland to encompass resources and resource using activities which influence or are influenced by the coastal area in both a direct and significant fashion.

The Department of Commerce is authorized to make grants to coastal states to assist in the development and administration of coastal zone management programs (Coastal Zone Management Act of 1972). The purpose of this legislation is to provide effective protection and economically and environmentally sound development of coastal zones. Once a State has formulated a program of coastal zone priorities, uses, and a system of legal controls for enforcement, it must be approved by the Department of Commerce. Once an approved State program is in effect, every applicant for Federal license or permit for an activity in the coastal zone must furnish a certification from the State that the proposed activity complies with the State's coastal zone management program.

Plans and activities under an extended navigation season program would be prepared so that conformity with the goals and objectives of the Coastal Zone Management Act is achieved. Coordination with State coastal offices is necessary for all projects which may affect the coastal zones, including the navigation season extension program. This coordination is effected through the Environmental Impact

Statement procedures with State Departments of Natural Resources. At present, only two of the eight Great Lake States (Michigan and Wisconsin) have approved coastal zone management programs. In this pre-operational phase of the project, since design and construction operations are not definitively known, consistency with individual states' CZM programs cannot be determined. However, under the Adaptive Methodology, the impacts on specific coastal areas would be assessed once they were identified in the detailed plans and specifications. Navigation season extension may affect areas of concern to States' coastal zone management, including:

a. Sensitive shoreline areas along the coastal zone (erosion and flood prone areas, wetlands, sand dunes, and islands);

b. historic and archaeological sites, and recreation areas;

c. port and harbor areas (intensive use areas, coastal lakes, river mouths, bays, urban areas); and,

d. water and air quality issues, and effects.

Impacts of coastal energy activities are also a concern, especially the transportation of oil, natural gas, and hazardous substances.

RECOMMENDED PLAN DESCRIPTION

This section presents a detailed description of the various elements and improvements which are considered necessary to achieve the study recommended plan 12-month navigation on the upper three Great Lakes, up to 12-month navigation on the St. Clair River-Lake St. Clair-Detroit River System and Lake Erie, and up to 10-month navigation on Lake Ontario and the International Section of the St. Lawrence River.

Results of engineering studies are displayed in the section of Attachment 2 of this Appendix entitled "ENGINEERING STUDIES."

Specifically, those system improvements and operational measures considered for implementation and necessary for extended season operation on the entire Great Lakes-St. Lawrence Seaway system are:

a. Lakes - Connecting Channels - St. Lawrence River

1. Icebreaking
2. Icebreaker Mooring Improvements
3. Vessel Traffic Control
4. Ice Data Collection/Dissemination Systems
5. Ice and Weather Forecasts
6. Aids to Navigation
7. Ice Control Structures
8. Air Bubbler Systems
9. Lock Modifications
10. Power Plant Protection
11. Dredging
12. Compensating Works
13. Shoreline Protection
14. Island Transportation Assistance
15. Connecting Channel Operational Plans
16. Water Level Monitoring
17. Vessel Speed Control and Enforcement
18. Safety/Survival Requirements
19. Vessel Operating and Design Criteria
20. Salvage Operations
21. Search and Rescue Requirements
22. Oil/Hazardous Substance Contingency Plans
23. Vessel Waste Discharge
24. Environmental Plan of Action
25. Pilot Access
26. Vessel Captain/Pilot Training

b. Harbors

1. Icebreaking
2. Ice Control Structures
3. Air Bubbler Systems
4. Aids to Navigation

Lakes-Connecting Channels-St. Lawrence River

Icebreaking

A vital part of extended season navigation is icebreaking support by vessels with icebreaking capabilities to render assistance to vessels whenever they are beset in ice or in need of assistance to transit through the ice. The U.S. Coast Guard, with its Great Lakes Headquarters (9th District) located at Cleveland, Ohio, has traditionally provided that support; however, it has only been at intermittent times when commercial vessels operating during the winter have needed assistance.

Currently, thirteen (13) Coast Guard vessels are engaged in icebreaking activities each year on the Great Lakes as part of the Winter Navigation Demonstration Program. This total includes two Type B vessels which are the MACKINAW and a polar class breaker; six Type C vessels which consist of four 140 foot and two 110 foot tugs; and five Type D buoy tenders. The Type B icebreakers are capable of breaking two to three feet of ice without backing and ramming. The 140 foot Type C vessels are specially equipped for icebreaking and are capable of breaking 1.5 to 2 feet of ice without backing and ramming. The Type D buoy tenders do not have significant icebreaking capability.

The Coast Guard's estimates of additional future icebreaking vessel requirements for the recommended plan are a total of four Type B and 20 Type C icebreakers. The areas of operation are:

Location	Type B	Type C
Western Lake Superior to the Straits of Mackinac	2	7
Lake Michigan	-	2
Lake Huron, St. Clair and Detroit Rivers, and Lakes St. Clair and Erie	2	7
Lake Ontario and the International Section of the St. Lawrence River	-	4

The major icebreakers (Type B) are deployed at strategic points in the lakes along major shipping routes and in areas of heavy ice concentration. These locations, along with Type C facilities, are more specifically described in the following "Icebreaker Mooring Improvements" Section.

During the summer months, these vessels would be used for search and rescue, law enforcement, boating safety and maintaining aids to navigation. It is for this reason that only 50 percent of the capital cost of new icebreakers is apportioned to extended season navigation.

Assumptions used in preparing the icebreaker requirements are as follows:

a. The icebreakers needed are for 12-month operation on the upper four lakes and 10-month operation on Lake Ontario and the St. Lawrence River.

b. Normal (average) winter ice conditions.

c. Commercial shipping to be able to use ports designated by U.S. Coast Guard District Commander.

d. Port icebreaking to be provided by port authority or shipping companies.

e. Only vessels with a horsepower to length ratio of 6:1 or greater and properly designed, equipped, and strengthened for ice would operate in ice-bound areas.

f. Convoying would be practiced for all multi-ship movements (a convoy will consist of not more than six vessels and one icebreaker).

g. No more than 12 hours of icebreaking per day per icebreaker.

h. Canadian port traffic would be handled in accordance with Canadian winter navigation policy.

i. U.S. Coast Guard would provide icebreaking in the St. Lawrence River from Lake Ontario to Massena, New York. Canadians would maintain waterways below Massena and in the Welland Canal.

These icebreaker requirements are based on the assumption that the shipping industry would improve the ice transiting capability of their vessels (horsepower to length ratio in excess of 6:1) and that icebreaking assistance in harbors will be provided by commercial icebreaking tugs. Under current programming and procurement restraints, the Coast Guard would be unable to procure the number of icebreakers called for before the mid-1980's. The base data used to compile these estimates consists of vessel transit projections for each area of the Great Lakes and the St. Lawrence Seaway. Commercial icebreaking activities may significantly reduce the number of Coast Guard icebreakers required.

Cost estimates for icebreaking requirements, contained in Table B-6 of this Appendix, include funding for the repair of Coast Guard vessels suffering damage while engaged in icebreaking operations. This is considered a portion of annual operation and maintenance costs.

A commercial fleet with adequate ice transiting capabilities, ice control and ice management measures (such as booms, bubbler systems, and harbor entrance modifications which are being proposed) plus advances in icebreaking technology would also tend to reduce the long term icebreaking vessel requirement projection.

A number of experiments have been conducted during the Demonstration Program with non-conventional icebreaking techniques, including saws, water jets, ice plows, and air cushion vehicles. None of these devices have shown significant potential as an icebreaking tool in the Great Lakes.

There are potential environmental impacts associated with an increased use of icebreakers during an extended navigation season. The propeller wash of deeper draft type "B" icebreakers cause strong currents and an underwater accumulation of ice along both sides of the track. The strong currents and ice buildups may have adverse environmental impacts, such as redistribution of sediments, increased turbidity, and possible resuspension of heavy metals and PCB's. Possibilities for disrupting animal movement, increasing the danger and limiting access to ice fishermen, and altering present water current and circulation patterns also exist. Studies to determine the impacts of these possibilities, and to develop mitigative procedures, are recommended in the Environmental Plan of Action (EPOA).

Icebreaker Mooring Improvements

Mooring facilities are currently provided for each Coast Guard cutter involved in icebreaking. Two changes have been required to previously existing Coast Guard mooring facilities as a result of the Winter Navigation Demonstration Program. The assignment of a second major icebreaker to the Great Lakes, WESTWIND, has resulted in the lease of mooring facilities in Milwaukee. One icebreaker operates almost exclusively from St. Ignace each winter to maintain traffic flow in the Straits of Mackinac. Leased mooring facilities have been acquired at St. Ignace.

In developing icebreaker mooring requirements, a number of assumptions were made:

a. Existing facilities will continue to be used and will be sufficient.

b. Facilities for Type B vessels (major icebreakers) will not normally exist and must be built.

c. At approximately 50% of the locations chosen for Type C vessels (140 foot WTGB class), sufficient dock space will exist and only services will need to be installed.

d. Specific locations are merely possible home ports and are subject to change.

The selected plan would require four icebreaker mooring facilities for Type B icebreakers proposed to be located at Duluth/Superior; Sault Ste. Marie (see Figure B-13); Detroit, Michigan; and Cleveland, Ohio (Figure B-47). Nineteen Type C icebreaker mooring facilities would be required at the following locations:

Sault Ste. Marie, 5 facilities (Figure B-13)
*St. Ignace, 1 facility
Escanaba, 2 facilities (Figure B-22)
Port Huron, 1 facility
Detroit, 2 facilities
Toledo, 2 facilities (Figure B-43)
Cleveland, 1 facility (Figure B-47)
Buffalo, 1 facility
Oswego, 1 facility (Figure B-53)
Cape Vincent, 1 facility (Figure B-54)
Alexandria Bay, 1 facility
Ogdensburg, 1 facility (Figure B-55)

*One existing facility would also be used at St. Ignace Harbor

In the process of constructing icebreaker mooring facilities, the following environmental impacts would be possible: danger to fish spawning sites (particularly those with overwintering eggs); placement of dredged material; and effect on neighboring wetlands. Each harbor where land acquisition and dredging of access channels is anticipated would need study. Normal permit procedures would be followed, and site specific environmental concerns would be taken into account as final decisions on the location of mooring facilities are made. Details of studies recommended are given in the EPOA.

Vessel Traffic Control

Vessel traffic control in the Great Lakes-St. Lawrence Seaway system under the recommended plan has been divided into three main sections. The first section is vessel traffic control for the prevention of collisions/rammings/groundings. The second section is vessel traffic control for voyage following assessment. The third section is vessel control for convoying and icebreaking scheduling assessment. The recommended solution for each area is considered independently of the others.

In the area of vessel traffic control for prevention of collisions, rammings, and groundings, no additional system is recommended in the area from Montreal to Long Point nor in the open lake areas of any of the Great Lakes. However, in the St. Marys River, when traffic conditions require two-way traffic in the Middle Neebish Channel (estimated 1995), a low light level closed circuit television is recommended to be installed at Johnson's Point and across the channel from Stribling Point. The installation will include transmission and associated control equipment. In the area of the Detroit-St. Clair Rivers, regulations would be established regarding vessel traffic and movement reporting. These regulations will incorporate existing regulations now at 33 CFR 162.135. Additionally, the establishment of a vessel traffic center is recommended during the period 1 December to 1 April. The vessel traffic center, to be located at or near an existing Coast Guard facility, will advise and, when necessary, control vessel traffic. Surveillance equipment beyond the existing speed control will not be necessary for this activity, but may be required for improved speed control for environmental or social reasons. Two remote transmitting sites with redundant Very High Frequency-Frequency Modulation (VHF-FM) communications equipment would be required, along with an adequate staff for the vessel traffic control central.

In the area of vessel traffic control for voyage following assessment, there is currently no reliable method of determining if a vessel has been lost or damaged (aside from the vessel communicating its own distress signal) until the vessel is overdue at its destination or until it has failed to file a routine report to its owner. Since the crew survival time is likely to be further reduced during the winter navigation operations, it is recommended that each vessel participating in the program be fitted with an emergency position indicating radio beacon, at the owner's expense. The emergency position indicating radio beacon is an automatic device which will transmit an alerting signal for a short period on channel 16 VHF-FM and a homing signal on channel 15 VHF-FM. Currently, U.S. Coast Guard units are being equipped with homing and direction finding equipment (these installations are not contingent upon season extension).

In the area of vessel traffic control for convoying and icebreaking scheduling, a Great Lakes automated vessel reporting system is recommended. To facilitate convoying and icebreaking, regular voyage reports (at call in points) would be required from all vessels except those on a scheduled run (e.g., ferries). These reports have been assessed and correlated with forecasts of ice conditions to form convoys and dispatch icebreakers during the Navigation Season Extension Demonstration Program. The existing Coast Guard communication facilities have thus far been able to handle the reports. However, considering the projected traffic, an automated system and additional radio operators would be required within 5 years. For the period from 1 December to 30 April, all vessels navigating in the Great Lakes would be required to participate in such a reporting system. At each of the present Coast Guard Task Group locations, terminal access to the reporting system will enable coordination of vessel movements for convoying. Such a

system would require vessels to be appropriately equipped, at the owner's expense, to participate. Five computer terminals and adequate staff would be required at Coast Guard Facilities.

Ice Data Collection/Dissemination Systems

During the Winter Navigation Demonstration Program, an Ice Navigation Center was established at the Ninth Coast Guard District Headquarters in Cleveland, Ohio. The Ice Navigation Center receives data from a variety of sources, compiles and analyzes the data, and disseminates the information in a near real time to interested users. It is recommended that the Ice Navigation Center be an integral part of the Winter Navigation on the Great Lakes-St. Lawrence Seaway system and operate at a level commensurate with shipping activity. The improvements recommended in order to provide adequate timely ice information services to the anticipated shipping traffic through the project life include an expanded staff capable of manning the facility on a 24-hour day, 7 day week basis, expanded physical facilities to handle increased personnel and equipment requirements, and new equipment, including a fully operational Side Looking Airborne Radar system (SLAR).

Ice and Weather Forecasts

To support the above mentioned Ice Navigation Center, ice and weather forecasts that were developed and implemented during the Demonstration Program are recommended. These ice and weather forecast require data collection, reduction, and analysis to provided timely ice and weather information. Additionally, it is recommended that twelve (12) site specific ice forecasts be developed for critical bays, harbors, and connecting channels. These site specific forecasts are needed to project the impact of ice conditions on navigation, as well as on other specific uses, such as island transportation, recreation, etc.

A forecast of ice breakup throughout the system would be necessary in scheduling the removal of ice booms in the spring and the deployment of aids to navigation.

Aids to Navigation

In the open waters of Lakes Superior, Michigan, Huron, Erie, Ontario and including Whitefish Bay, Green Bay, and Grand Traverse Bay, all weather aids to navigation are necessary for the navigator to accurately determine his position and to assist him in affecting a safe transit in open waters of the Great Lakes. The LORAN-C is the Federal Government-sponsored navigation system for the U.S. Coastal Influence Zone. This system includes the Great Lakes. As the requirement for having LORAN-C receiving equipment on board vessels by 1 June 1981 is met, the mariner will have available a twelve month all-weather navigation system that is in addition to the existing system of major lake coast lights, radio beacons, fog signals, and RACONS.

In Great Lake Harbors and connecting channels, all lighted buoys and radar reflector equipped unlighted buoys were traditionally withdrawn during late November and December to prevent damage and/or loss of the aid during the winter months. Some of these buoys are replaced with unlighted buoys not equipped with radar reflectors. The winter markers are barely adequate at best and represent a significant reduction in effectiveness. Buoys are also subject to being submerged or carried off station by moving ice. Since the reliability of floating aids during the winter navigation period marking channels is reduced, vessel personnel are often times uncertain as to their exact position within the channel. Thus, the probability of grounding is increased considerably because the aids may be off station or under the ice. Therefore, a system of fixed light structures, some equipped with radar transponders (RACON), and a Mini LORAN-C system is recommended. Since the mariner has become

heavily reliant on radar, the Mini-LORAN C will not eliminate nor even reduce significantly his dependence; therefore, both systems are recommended. During reduced visibility, when he is depending on the LORAN C system for his position, he must also use his radar to determine the location and direction of other traffic with respect to his vessel. It is believed that the two systems, the LORAN C and fixed channel markers, complement each other and will ensure that maximum benefits are derived from each. The results of feasibility tests to date along the St. Marys River, aboard the Coast Guard vessel NAUGATUCK, the icebreaker MACKINAW, and the ore carrier ARTHUR M. ANDERSON, indicate that the LORAN-C system looks promising for high-precision navigation. The specific recommendations are as follows: six fixed navigation light structures in Duluth Superior Harbor, one each (navigation light structures) at Birch/Brush Point and Big Point as well as eight fixed navigation lights structures in the St. Marys River, four fixed navigation lights in Green Bay, one fixed navigation light in Alpena, two fixed navigation lights in Saginaw Bay, four fixed navigation lights in the St. Clair and Detroit Rivers, and one fixed navigation light with RACON in Toledo Harbor. The configuration of other harbors in the Great Lakes is such that additional aids are not required. The St. Clair and Detroit Rivers will also be in line for a mini LORAN-C Chain, after the effectiveness of the St. Marys Chain has been thoroughly evaluated and shipboard receivers are readily available in the commercial market.

The fixed aids to navigation in the St. Lawrence River required for the recommended plan in U.S. waters are as follows: twelve fixed aids, two ranges, and the addition of nineteen radar reflectors to existing fixed aids. An important rationale for these winter transportation system improvements on the Seaway is to provide for safe night time transit, thus increasing the overall capacity of the Seaway.

Ice Control Structures

On the St. Marys River, immediately upstream of the Sugar Island Ferry crossing, in Soo Harbor, the ice cover would be stabilized by an ice boom system, a number of ice anchoring islands, and the extension of the sewer outfall of the Sault Ste. Marie Sewage Treatment Plant (See Figure B-13). The ice boom system is currently comprised of a 400-foot west boom extending from Mission Point and a 1,000-foot east boom extending from Island "G", a small island adjacent to Sugar Island. A 250-foot wide opening would be left between the outer ends of the booms in the navigation channel for vessel passage. Booms have been built at this location under the Demonstration Program and would be redesigned and reinstalled for the long range program. A typical river ice boom and boom anchors are shown on Figures B-14 and B-15. To prevent rotation of the ice field above the boom on the south side of Soo harbor, two rubblemound islands would be constructed adjacent to the south channel line to anchor the field. The sewage treatment plant outfall would be extended from its point of exit from the plant parallel to the south shoreline of Soo Harbor to a point immediately upsteam from the west Sugar Island Ferry dock. This change in location of the outfall would allow the Soo Harbor ice field to remain shorefast and would help to maintain the west dock of the Sugar Island Ferry in an ice free condition.

There are potential environmental impacts associated with the modification of ice booms and the relocation of sewage outfall that deserve study. In addition to impacts associated with dredging in the anchors, there may be changes in a variety of physical and chemical parameters important to fish and wildlife; i.e., current patterns, resuspension of pollutants, etc. The stabilization of ice may have a beneficial impact should the provision of increased safety enhance ice fishing in stabilized areas, in addition to reducing the

prospects of ice jams and flooding in the spring. Site specific studies in the Soo Harbor and other locations described would be necessary to determine present resource values and the extent of possible impacts resulting from the installation or modification of ice booms. These studies are addressed in the EPOA.

At the lower end of Lake Huron where it passes into the St. Clair River, in the vicinity of Port Huron, Michigan, and Sarnia, Ontario, an ice boom system is recommended to stabilize the natural ice arch which can be disturbed by passing vessels (See Figure B-37). The boom would be the heavy duty type, likely with "catamaran" floats to give it increased stability against the wind driven ice of Lake Huron. There would be booms extending from both shorelines at a distance of approximately 5,000 feet upstream from the Bluewater Bridge which connects Port Huron and Sarnia. The west boom section would be approximately 1,200 feet long, and the east boom section would be approximately 3,200 feet long. An opening approximately 500 feet wide would be left between the boom ends at the navigation channel to allow for vessel passage. A model study is being conducted to refine the detail of the ice control measure needed in this area.

The installation of ice control structures in the St. Clair River would alleviate two problem areas in the river. The ice booms would help to keep heavy ice cover from blocking the cooling water intakes at power plant sources and the booms would also help to keep the channel open so ferry operations would not be hindered.

At the lower end of Lake St. Clair where it passes into the Detroit River, in the vicinity of Detroit, Michigan, and Windsor, Ontario, an ice control system is recommended to stabilize the natural ice arches which form between the U.S. mainland, the channel islands, and the Canadian mainland (See Figure B-40). The purpose of

the ice control system is to maintain the natural ice arches which could be disturbed by passing vessels. The system as now designed would be an ice boom and would be constructed in three sections and located a few hundred feet upstream of Peach Island. A 1,600-foot section from the Canadian mainland to Peach Island, a 3,200-foot section from Peach Island to the navigation channel, and a 1,200-foot section from the navigation channel to the U.S. mainland would be constructed. An opening approximately 500 feet would be left between the boom ends at the navigation channel to allow for vessel passage.

On the St. Lawrence River in the vicinity of Ogdensburg, New York, and Prescott, Ontario, there exists an ice boom which has been constructed to stabilize the ice cover for power production purposes (See Figure B-55). This boom would be relocated, reconstructed, and equipped with a navigation opening at the point where it intersects the navigation channel. The boom would be approximately 2,000 feet long, would have the heavy duty type "catamaran" floats, and the navigation opening would be equipped with approximately 1,000 foot sections of light duty booms running parallel and upstream from each boom end. These light duty booms are provided to resist the tendency of the ice field to break off because of vessel induced forces as it passes through the boom opening. The navigation opening would be approximately 250 feet wide.

Also, on the St. Lawrence River in the vicinity of Cardinal, Ontario, and Galop Island, there exists an ice boom system which has been constructed to stabilize the ice cover for power production purposes (See Figure B-55). This navigation channel boom would be reconstructed and equipped with a navigation opening at the point where it intersects the navigation channel. The boom would be approximately 3,300 feet long, would have the heavy duty type "catamaran" floats, and have a navigation opening approximately 250 feet wide.

In addition to the Ogdensburg-Prescott and Galop Island booms, there would be nine additional booms placed in the St. Lawrence River between the Ogdensburg-Prescott bridge and Morrisburg, Ontario. Six would be upstream from the Iroquois Dam and three downstream (See Figure B-55). The booms would vary from 1,200 feet long to 6,000 feet long and would be both heavy and light duty types, depending on location.

With regard to modifying existing ice booms, two alternatives have been explored. The first, described in several cases above, involves removing a section of the main boom, thereby creating a navigation opening. The second possibility is to construct gated openings. The recommendation in favor of the first alternative was based on favorable economics and the fact that opening and closing of the gate against the force of moving ice could prove difficult and cause delays in vessel transit. Experience has shown that the natural ice arch re-establishes itself quickly after a vessel passes through an ungated opening, and that the amount of ice released through the opening is normally small, contributing little to downstream ice problems.

Based upon test results of the Demonstration Program on the St. Marys River and results of physical and mathematical model tests completed or underway, sufficient engineering data exists to recommend a substantial season extension in the St. Lawrence River, even without dredging, utilizing ice stabilization structures, reducing vessel draft, or alteration to the currently authorized operational regulation plan.

The complexities of the hydraulics of the St. Lawrence River, as they could affect power production, shorelines, navigation, and the ecological systems of the river, strongly suggest that limited tests of vessel transits through an ice boom or booms under a full ice

cover condition would be necessary during the recommended post authorization phase of a Navigation Season Extension Program. Physical engineering tests would be used to verify results of previous model tests. Therefore, it is proposed that physical engineering tests be conducted in the reach of the St. Lawrence River between Ogdensburg, New York, and Galop Island during the Phase I, GDM, following environmental baseline data collection and environmental assessment, as outlined in the Environmental Plan of Action.

Additionally, physical model tests are proposed during the Phase I GDM, for the St. Lawrence River reach between Cardinal, Ontario, and Iroquois Lock and Dam and mathematical models of the reach between Morrisburg, Ontario, and Moses-Saunders Power Dam. It is also proposed that vessel transit tests of the system be conducted to confirm the results of these model tests.

Air Bubbler Systems

The St. Marys River throughout its length has a number of tight turns in the navigation channel. Vessels encounter serious difficulty negotiating these turns because of frictional resistance between the vessel hull and the ice field. Specifically, the tight turns which have been identified as causing the most problems are:

Whitefish Bay, Birch Point Turn	(See Figure B-9)
Middle Neebish Channel, Angle Courses 5-6	(See Figure B-19)
Middle Neebish Channel, Angle Courses 6-7	(See Figure B-19)
Middle Neebish Channel, Angle Courses 7-8	(See Figure B-20)
Middle Neebish Channel, Angle Courses 8-9	(See Figure B-20)
Lime Island, Lime Island Turn	(See Figure B-21)

A typical channel bubbler and compressor facility is shown on Figures B-10 and B-11. The installation of bubbler systems at each of these tight turns would inhibit the formation of ice or melt a portion of the ice field which may have already formed. The bubbler pipe would be placed at the edge of the navigation channel, thus producing a relief zone in the ice field adjacent to the vessel track to ease the movement of the vessel in the track. The bubbler would emit air at a pressure of 10 to 15 pounds per square inch. The bubbler dispensing pipe would be supplied by a pipe leading from a shore based compressor facility. The bubbler lengths would be 3,500 feet at Angle Courses 7-8 and 8-9, 5,000 feet at Angle Courses 5-6 and 6-7 and Lime Island Turn, and 10,000 feet at Birch Point Turn. The air would be compressed by a 375 cubic feet per minute diesel powered compressor, and a second compressor of the same capacity and type would be installed as a backup.

The compressor facility would also be equipped with after coolers and air driers to cool the compressed air and remove moisture to prevent condensation on the walls of the pipe. Otherwise blockages could occur. The compressor equipment would be housed in a small prefabricated building.

Though not expected, air bubbler systems may have some adverse environmental impacts. Unless operated so as to maintain a thin coating of ice, open water created by the systems may increase waterfowl utilization in areas where they may be subject to increased mortality from weather, disease, or inadequate food supply. Bubbler systems may affect aquatic fauna and their carrying capability through oxygenation of the local waters, and inhibit movement of fish and wildlife. These possibilities and others will be explored in studies to be accomplished in the EPOA.

Lock Modifications

The problems of operating the Soo Locks (Figure B-12) throughout the full winter period fall into seven broad categories as follows:

Lock Walls
Gates
Upstream Approach
Downstream Approach
Lock Equipment
Bottom Scouring
Floating Plant to Support the Locks

The solutions recommended are discussed below:

Coating of the lock walls with a co-polymer coating and removing the ice that does adhere by using portable steam hoses with nozzles would handle the general lock wall areas. The installation of a steamline in the Poe Lock, by providing a recess in the concrete along the lock wall at ice collar level, was considered as well. Other alternatives investigated, such as using a tractor-backhoe unit, a tractor-mounted 16 ft. chainsaw bar, and a scraper blade mounted on a tug, were considered less desirable. These possibilities were seen as more capital and labor intensive, and less automatic in nature; thus, they were considered less favorable.

Damage to the wood timber fenders along the lock walls would increase under an extended navigation season, and as initial experimentation with rubber fenders has not been satisfactory, increased budget allowances for the added costs of replacement in terms of material and labor would be necessary.

To remove ice which accumulates in the lock chamber, butterfly valves would be installed in the upsteam lock gates. These butterfly valves, along with the use of a tug to herd ice from the dead water areas of the lock, would adequately handle the ice accumulation in the lock chamber.

Ice in gate recesses would be removed by installing a bubbler flusher, which would be operated as just a bubbler during periods when there are no vessels and as a flusher only during locking cycles. Also, a co-polymer coating would be applied to the gate and gate recess to minimize ice adherence. A high velocity pump system would be installed to flush ice from the groin or heel area of the upstream gates. Heating cables would be installed on gate recess machinery to prevent ice buildup.

The lock safety boom would have to have a permanent housing constructed around the rolling segments to keep the tracks, teeth, and recess pit free of ice and snow. The boom tips would be provided with panels to protect the sockets from blowing snow, the boom recesses would have the backwater valve for the floor drains modified to prevent improper seating, and heating cables would be installed on the floor near the drains to prevent freezing.

Ice problems in the upstream lock entrance of the Poe Lock would be handled by the construction of a bubbler air curtain across the upper lock approach; a bubbler system along the approach channel or pier, and ice boom above the MacArthur Lock; the herding, by a small tug, of ice through the MacArthur Lock; and the heating of the pier walls to keep ice from adhering to them. Other options, such as flow developers and ice harvesting, would not be fully effective nor cost efficient.

The ice problems in the downstream lock entrance of the Poe Lock would be handled by the placement of a bubbler along the pier; the installation of large gate valves to flush the area immediately below the lock gates; and the operation of a tug and sweeping boom to move ice into the large areas not used by traffic, such as north of the East Center pier. An air curtain bubbler across the channel in the lower approach would not be a solution in this instance. Also, flow developers would not add significantly to the flushing action of ice being forced from the lock. Finally, a tailrace diversion from the U.S. power plant at the location was not seen as practical due to the distance and cost involved.

Because of the added requirement for compressed air for bubblers, two-2,000 cfm compressors would be necessary to replace the existing obsolete and under capacity units. Similarly, the additional requirements for steam for ice removal would necessitate the replacement of the existing rebuilt boiler. The probability of damage to lock equipment and structures would increase with winter navigation, making necessary an increased level of maintenance. This would include even the need for more frequent gate repainting.

Therefore, extended winter operations through the Soo Locks would require adjustments in the scheduling of maintenance operations. Some of the above-water mechanical maintenance and concrete repair work would have to be phased or staggered to be accomplished with the lock operational.

The shoals which result from bottom scouring would be removed as necessary as a part of the normal shoal clearing operations. Removal of deposition from bottom scouring would become a more extensive operation; however, four alternatives have been investigated to find ways of meeting the problem. These include: (1) contract out a portion of the total maintenance dredging requirement to compensate

for the additional shoal removal work caused by winter navigation; (2) temporarily assign a derrickboat from other Corps of Engineers offices for a period each summer; (3) remove the loosened rock below grade by dredging; and (4) request authority to allow for payment of overdepth dredging on future dredging contracts. The first alternative is recommended on the basis that existing plant personnel are fully committed to known maintenance dredging requirements. Alternative 2 has some merit but could only be implemented if plant personnel were available from other Corps offices, and this could not be planned for on a long-term basis. The cost of Alternative 3, and the lack of assurance that it would eliminate the problem, would serve to exclude this option from further consideration. It is recommended that Alternative 4 be considered on future projects for dredging those channels that are susceptible to shoaling because of winter navigation operations.

Winter operation would require the use of Corps of Engineers tugs, derrick boats, and gate lifters to maintain and repair ice control facilities. The tug FREDERICK would need to be repowered (new 700-900 Horsepower engine), the bow would need to be reinforced for minor ice breaking, a heavy duty propeller installed, a new stronger steering gear system installed, and fuel tanks modified to provide a "double bottom" characteristic. The tug WHITEFISH BAY would require strengthening of the bow plating and framing, replacement of the cable type steering system with a hydraulic system, installation of a heavy duty propeller, modification of the sea chest to remedy problems related to ice operations, and modifications of the fuel tanks to provide a "double bottom" characteristic. In addition, a new 1,200 to 1,600 horsepower tug, not longer than 65 feet because of 80 foot lock width, would be necessary. The derrick boat HARVEY would require strengthening of the hull, installation of heaters and heated inclosures around the spud wells and deck machinery, and the installation of a large

capacity air dryer for the compressed air system. The gate lifter PAUL BUNYAN would require replacement of the existing steam power plant with a diesel power plant that could operate in the on and off mode required in the winter, and installation of heating equipment and an insulated inclosure for each spud well.

There are two navigation locks on the St. Lawrence River that are U.S. owned (Eisenhower and Snell, see Figure B-57). The other five are Canadian owned (see Figures B-56, B-60 and B-62). The problems, related to winter navigation at these locks, can be grouped into four categories as follows:

Lock wall icing
Gate icing
Ice in the lock chamber
Equipment failures

The recommended solutions to the problems in each of these categories are discussed below. The improvement necessary to handle lock wall icing consists of coating the lock walls with a co-polymer coating and removing the ice with portable steam hoses with nozzles. The improvements necessary to handle gate and gate component icing consist of heating the mating edges of the gates, the installation of gate recess bubbler flusher, and replacing the existing contact blocks with heated contact blocks. The improvements necessary to handle ice in the lock chamber are the installation of flow developers in the lock walls to speed the passage of ice out of the upstream end of the lock chamber, and the installation of flow developers along the approach walls. The improvements necessary to handle the probable higher incidences of equipment failure would require that all equipment and lock subsystems be kept in a high state of maintenance, that extensive equipment redesign be undertaken, and that heated enclosures be provided for equipment and personnel.

To operate and maintain lock facilities and ice booms on the St. Lawrence River, two tug boats would be needed. The existing SLSDC tug ROBINSON BAY would have to have a new stainless steel propeller installed and an air lubrication system installed for the hull. Also, a second new icebreaking tug is recommended.

Power Plant Protection

The Edison Sault Power Plant on the South Bank of the St. Marys River, in Soo Harbor, immediately downstream of the Soo Locks, (See Figure B-13) is susceptible to flooding from tailwater river stages of elevation 582.9 feet. This elevation can be reached or exceeded if ice jams occur in the Little Rapids Cut. The rise required to produce flooding is only a couple of feet above normal range of river stages. However, Edison Sault Electric Company states that it does not feel that it would be advisable to make any major expenditures to prevent plant flooding inasmuch as the plant has been flooded from the tailrace side only once in 78 years of operation. This flooding occurred in December 1951 and was caused by an ice jam at Six Mile Point in the lower river. There were sixteen compensating gates open at the time and it took thirty hours for the water to raise 2.6 feet. The ice boom which is being constructed at the lower end of Soo Harbor (head of Little Rapids Cut) would stabilize the ice cover in Soo Harbor, thus minimizing the passage of ice through Little Rapids Cut and the possibility of ice jamming at the lower end of Little Rapids Cut. The boom details have been addressed in the Ice Control Structures discussion.

The power plants along the St. Clair and Detroit River could be affected by ice dislodged from the natural ice arches, at the head of each river, by vessels which pass through the arches. As in the case of the St. Marys River, the details have been addressed in the Ice Control Structures discussion.

The Moses-Saunders and Beauharnois Powerhouse on the St. Lawrence River have been affected by ice jamming through the years, and the Power Entities have addressed this problem by constructing ice booms at Ogdensburg-Prescott, Galop Island, Lake St. Francis, and the Beauharnois Canal. The existing Ogdensburg-Prescott and Galop booms extend across the entire river including the navigation channel. As in the case of the other rivers, the details of boom modifications and additional booms have been addressed in the Ice Control Structures discussion.

Dredging

Under an expanded navigation season, the anticipated increase of winter transits on the St. Marys River around Neebish Island would eventually require the provision of simultaneous two-way traffic in the Middle Neebish Channel. This would require the dredging of the existing one-way 300 foot wide Middle Neebish Channel to transform it into a 700 foot wide two-way channel (see Figure B-16). The dredging would amount to approximately 3,000,000 cubic yards of limestone and soft materials, depending on the location in the approximately 17 mile long channel (for typical dredging cross-section, see Figure B-17). It is recommended to dispose of the dredged material by hauling it to an open water area in the head of Lake Huron where the water depths are between 100 and 150 feet (see Figure B-18). The possibility of upland disposal at an area or areas closer to the dredging site was investigated but no sites could readily be identified. The possibility of upland disposal site would be further pursued during the design memorandum phases of this project. Additionally, the disposal of a portion of the dredged rock in patterns and configurations which may improve and diversify the aquatic habitats of Lake Munuscong appears to be a viable alternative which would be investigated in the design memorandum phases.

Alternatives considered were: (1) close Middle Neebish Channel and dredge West Neebish Channel to permit simultaneous two-way traffic; (2) close Middle Neebish Channel and operate West Neebish Channel for alternating two-way traffic with traffic controls; (3) close West Neebish and operate Middle Neebish for alternating two-way traffic with traffic controls; and (4) continue the existing summer traffic pattern. The first alternative was ruled out by dredging quantities roughly seven times greater than would be necessary in the Middle Channel under the recommended plan. The major drawback of the second and third alternatives, that of arranging alternating two-way transit in either channel, is the potential for bottlenecks as the volume of traffic increases in the future. The fourth alternative, operating the Middle Neebish Channel for upbound traffic and the West Neebish Channel for downbound traffic, presents serious uncertainties regarding possible ice jamming in the West Channel and possible flooding and shore erosion problems upstream of the West Neebish Channel. Until the system reaches capacity and the decision on when to begin dredging is made, the practice of alternating two-way traffic in the Middle Neebish Channel with traffic controls is expected to continue as it has during the Demonstration Program. Concerns about other potentially severe environmental consequences along the West Channel have also been expressed.

Assuring cross channel transportation for Neebish Island residents is another consideration which strongly favors the Middle Channel option.

Any alternative selected to improve winter transit around Neebish Island, regardless of the dredging undertaken, would involve costs in the form of bubbler systems at crucial turns, additional icebreaker assistance, additional traffic control monitoring, and navigation aids effective for winter use. These items are discussed at appropriate locations in this Appendix.

All the alternatives could have environmental impacts as well. Those associated especially with dredging activity include a displacement of bottom habitat, possible changes in current patterns and velocities, and possible resuspension of pollutants. Disposal of dredged material has the potential to adversely or beneficially affect the environment depending on where, how, and what type of material is placed to promote specific use objectives. It should be remembered that some dredging activity would likely take place in any case in the process of maintaining the shipping channels around Neebish Island for non-winter season shipping.

Compensating Works

On the St. Clair River at Stag Island, river flow compensating works are recommended (See Figures B-38 and B-39). The compensating works would be made up of a 1,500 foot training wall extending northerly from the northern end of Stag Island, and a 300 foot gated structure extending from the Canadian mainland partially across the channel east of Stag Island. The training wall would be trapezoidal in cross-section with a random rockfill core and riprap outer covering. The gated structure would be equipped with buoyant flapgates. The gate supporting structure would be large cellular reinforced concrete sills with steel sheet pile cells at each end. The top elevation of the structures would be approximately 10 feet above low water datum (LWD=574.7').

On the Detroit River at Peach Island, river flow compensating works are also recommended (See Figures B-40 and B-41). The compensating works would be made up of two-1,500 foot training walls, which would run parallel to and at the channel-lines of the 800 foot wide navigation channel; a 350 foot gated structure between the north training wall and the U.S. mainland; and an 800 foot gated structure extending partially across the river from the south training wall toward Peach Island. The training walls would be trapezoidal in

cross-section with a granular core, random rockfill outer mass, and riprap outer covering. The gated structures would be equipped with buoyant flapgates. The gate supporting structure would be large cellular reinforce concrete sills with steel sheet pile cells at each end. The top elevation of the structure would be approximately nine feet above low water datum (LWD = 571.31).

Though their purpose is environmentally oriented, to maintain natural levels and flows compensating works may possibly change water levels and current patterns, with potential environmental consequences. Resuspension of pollutants and disruption of Lake Sturgeon spawning and feeding grounds are potential problems that would need examination in the form of baseline and monitoring studies.

Shoreline Protection

Shoreline Erosion Protection

As part of the effort to analyze the role of ice and winter navigation in sediment transport and shoreline erosion, a study is underway to complete identification of erosion prone areas within the Great Lakes, their connecting channels, and the St. Lawrence River that are considered to be influenced by winter navigation. The approach being taken in this study is to describe the mechanisms of ship-induced impacts to provide a base of understanding, and then define relevant impact areas of the shoreline and make an estimate of the magnitude of potential problem areas. Preliminary estimates of shoreline lengths that appear particularly susceptible to ship-induced erosion effects along the Great Lakes connecting channels and St. Lawrence River are: St. Marys River, 4.8 miles; St. Clair River, 0.75 miles; Detroit River, 0.77 miles; and the St. Lawrence River, 3.2 miles. Cost estimates for permanent shoreline erosion protection are displayed in the cost tables for the recommended plan.

Shore Structure Protection

As part of the shoreline protection study, studies identified structure damage prone areas within the Great Lakes, their connecting channels, and the St. Lawrence River. The problem is to evaluate the change in the incidence and degree of damage incurred by private structures under extended navigation. The approach to a solution would measure actual ice forces and compare them with stability and strength criteria for various structures, leading to an assessment of potential damage under actual conditions of extended navigation. However, the data necessary for such an analysis are not extensive enough nor sufficiently documented to give confidence in applying them to so great a number and variety of structures, ice conditions, and channel configurations. There are up to approximately 4,700 structures that would be possible candidates for protection.

A probabilistic approach has been developed to assess both the incidence and degree of ice damage to structures. This approach is consistent with the belief that analytical certainty is not obtainable, and yet the probabilistic approach can adequately serve the planning function by providing information that is sufficiently precise to support planning conclusions and actions, including preliminary cost estimates.

The probabilistic approach consists of characterizing the ice conditions, on a reach-by-reach basis, that occur under natural conditions and under several schemes of winter navigation. On the basis of these ice conditions and on the basis of the channel characteristics within each reach, two probability estimates are made. First, estimates are made of the probability of occurrence of ice damage in each reach. Second, estimates are made which express the likely severity of ice damage in each reach in probabilistic terms. There remains the need to translate the probability estimates

into terms more tangible, such as dollar cost. This is done by expressing ice damage costs as a function of the total value of the structures, or more specifically, as a portion of percentage of total value. For the purpose of this study, it was decided to express value in terms of cost of replacement by like construction.

Estimates of the dollar value of ice damage to shore structures along the Great Lakes connecting channels and St. Lawrence River are displayed as a one-time shore structure compensation cost for permanent protection in the cost tables of the recommended plan.

Shore Protection Conclusion

The possible courses of action and recommendation on shoreline erosion and structural damage were discussed earlier in this appendix under the Social Well-Being Impacts section.

Environmental impacts of actively eroding shores and channel bottoms, and their effects on fish and wildlife in the areas concerned, are addressed in the Environmental Plan of Action.

Island Transportation Assistance

Sugar Island Ferry - The continuous passage of vessels through the natural ice arch at the head of Little Rapids Cut causes ice to break away from the arch and could eventually cause the Cut to fill with ice and interrupt ferry passage. The recommended solution to these problems has been tested under the Demonstration Program. For a permanent solution, the mainland dock bubbler flusher and the ice booms recommended under the March 1976 Interim Report would be redesigned and replaced with facilities for year-round navigation. To stabilize the ice field in Soo Harbor, ice islands would be constructed and the sewer outfall from the Sault Ste. Marie sewage

treatment plant would be extended. All of these construction items have been discussed and included under the section entitled Ice Control Structures. Other possible solutions, such as helicopter or air boat service, or bridge construction, would be either extremely costly or not totally effective in transporting supplies (e.g., fuel oil) as well as residents and vehicles.

Lime Island - The construction and operation of an airboat has been recommended under the plan for extension of the navigation season to 31 January. It has been further suggested that a one-time lump-sum payment be made to a non-Federal entity, which would then be responsible for the operation and maintenance of the airboat. Permanent transportation facilities are not deemed feasible given the extreme costs that would be necessary to service the needs of the small number of permanent residents.

For purposes of the extended season navigation through the full winter season, only the additional increment of operation and maintenance costs have been recommended in this report.

Drummond Island Ferry - The continuously maintained ship track, upstream of the ferry crossing, severs the alternate means of transportation to the mainland when the primary means (the ferry) is out of service for repairs.

Detailed studies of island transportation were conducted at Drummond Island during the Demonstration Program to determine if there was an impact of winter navigation on the island transportation between the island and the mainland at Detour, Michigan. The results of the study indicate that the impact of winter navigation was on the alternative mode of transportation to and from the island (over-the-ice) and not on the ferry transportation. Consequently, no improvements are recommended for Drummond Island. Further

observations would be conducted during the advanced engineering and design phase to confirm whether or not extended season operations significantly hinder efficient operation of the ferry. If further investigations determined that extended season operations impact on ferry operations, mitigation measures would be considered.

Grindstone Island - In the St. Lawrence River, winter vessel movement would create transportation problems for Grindstone Island residents, in that their ice bridge direct to the Village of Clayton would be disrupted. One solution would have residents make their way to Wellesley Island by the same means that they have used to cross the channel to the mainland, and from Wellesley Island commute by automobile over the Thousand Island Bridge and on to Clayton. This would necessitate Grindstone winter residents stationing their automobiles on Wellesley Island. The overall distance of this alternate route is approximately 10.75 miles. As this solution is not considered acceptable to the island residents, the provision of a tug that is capable of operating between Grindstone Island and Clayton, during periods when the river is ice covered, is the recommended solution for providing winter access directly between Grindstone Island and Clayton, New York. The operations of this tug would require the dredging of approximately 4,000 cubic yards of rock to provide adequate water depth at the Grindstone Island dock. Some minor modification to the dock structure would also be needed. Adequate docking facilities already exist at Clayton.

Use of an airboat on a year-round basis is a feasible alternative for those island residents who own this mode of transportation. However, only a few of the Grindstone Island residents own this form of transportation.

Bridge construction, helicopter transportation, or the use of an all-terrain vehicle are also judged to be excessively costly solutions.

Detailed studies of island transportation were conducted in the St. Clair and Detroit Rivers to determine if there was a potential impact of winter navigation on those transportation systems. The results of the study indicate that the impact of winter navigation on cross-channel transportation service is minimal. Consequently, no improvements are recommended for the St. Clair River and the Detroit River, with exception of a review of impacts on the Harsens Island Ferry. Should there be impacts attributable to extended season operations, mitigation measures would be considered.

Connecting Channel Operational Plans

As a further assurance that the impact on island transportation is minimized, contingency plans for Sugar Island, Neebish Island, Lime Island, and Drummond Island in the St. Marys River are recommended for implementation. These plans were developed and successfully implemented during the Winter Navigation Demonstration Program.

The operational plan for Sugar Island ferry transportation contains considerations for icebreaking assistance for the ferry, ice condition forecasts, public notification of ice forecasts, and criteria to be used in determining the closing date for winter navigation, should it become necessary. Measures to be taken during temporary ferry service interruptions are the use of a Coast Guard tug equipped with wind shelters for emergency ferry service, temporary landing facilities for the Coast Guard tug, and provisions for Dial-a-Ride service to be provided by the Eastern Upper Peninsula Transportation Authority, in addition to structural measures already recommended. These items recommended are stabilization measures for the Soo Harbor ice cover and the provision for a bubbler-flusher at the mainland dock to assist in keeping the ferry landing clear of broken ice.

The operational plan for Neebish and Lime Island's transportation contains consideration for emergency ferry and medical evacuation service.

The operational plan for Drummond Island Ferry Service contains consideration for icebreaking assistance, emergency ferry service provided by the U. S. Coast Guard, land transportation service, public notification of anticipated ferry difficulty, and emergency medical evacuation service.

Additionally, similar operational plans would be developed and implemented for islands in the St. Clair and St. Lawrence Rivers. They would contain provisions for emergency ferry service, emergency medical evacuation, and icebreaking assistance, as required.

This activity would be funded under existing agency authorities; consequently, there is no cost associated with the recommended plan.

Water Level Monitoring

It has been shown by various investigators that ice retardation within the Great Lakes connecting channels can affect the levels and flows of the system. This natural occurrence is an important factor in the natural water levels existing in the system. Winter navigation can disrupt the ice cover in these reaches and, as a result, might increase or decrease this retardation, which in turn would affect the levels.

Consequently, it would be necessary to increase the monitoring systems in the connecting channels of the Great Lakes. Ice jam alert monitoring programs have been established for the St. Clair River, Detroit River, and St. Marys River and would be established for the St. Lawrence River. Water level monitoring under these plans would

be conducted with the use of water level recording gages as well as on-sight inspections. Additionally, time-lapsed motion picture cameras would be used to monitor ice conditions in critical reaches of the system, and it would be necessary periodically to make ice thickness measurements and current velocity measurements as well as aerial reconnaissance flights to assess the overall ice conditions.

Vessel Speed Control and Enforcement

Speed regulations are the responsibility of the U.S. Coast Guard and the St. Lawrence Seaway Development Corporation. These regulations are found in 33 CFR 92.49 (St. Marys River), 33 CFR 162.135 (Detroit-St. Clair River) and 33 CFR 401.28 (St. Lawrence River).

Vessel speeds are monitored using Doppler radar or by measuring the time a vessel travels its own length. During the regular navigation season, vessel speeds are checked at random locations at random times of the day or night. During winter navigation, the level of speed monitoring is reduced commensurate with vessel traffic levels. Civil penalties are assessed for significant violations.

Vessels, including icebreakers, can be expected to operate at speeds ranging from 0 to 15 miles per hours or at the established speed limits, whichever is lesser. New electronic navigation devices, which would indicate vessel speed, would have no effect except that it will be easier for vessel personnel to comply with the speed limits. The Coast Guard indicates that compliance is already very high.

In addition to messures recommended by this report (see Social Well-Being Section), assessment of reports of property damage would continue (U.S. Coast Guard/SLSDC) with a view toward adjusting the

speed limit should experience indicate it necessary. Vessel operators will continue to be responsible for shore property damage; this will continue to place any financial burden directly on the responsible parties. The decisions regarding the causes of damage, either natural or vessel wake, would be determined on a case by case basis.

This activity would be funded under existing agency authorities; consequently, there is no cost associated with the recommended plan.

Safety/Survival Requirements

The technical developments for crews' safety and survival have either been completed or are nearing completion by the U.S. Coast Guard. Technical requirements are either established or in their final development. The task that remains is to introduce the necessary changes to the Coast Guard regulations through the extended process of legal review, publication of proposed rules, evaluation of public comment, additional legal review, and final rule publication.

The Coast Guard will continue the process of translating the technical developments into proposed and final rules. One result of climatological and environmental studies was the realization that hazards to crews were just as great during parts of the normal navigation season as during the extended navigation season. Therefore, regulation changes that would be proposed will apply, for the most part, to inspected vessels of the Great Lakes in general and not just to those operating during the extended season. Regulation projects that are in process at this time include provisions for:

a. Exposure suits for all personnel on-board.

b. Inclosed survival craft capable of being launched with all personnel aboard.

c. Emergency Position Indicating Radio Beacon (EPIRB) for vessels and survival craft.

d. Improved crew training and drill requirements, including instruction in cold water survival techniques.

All costs incurred in introducing the new required equipment and training would be borne by vessel owners and operators as part of their overall safety program.

The Coast Guard has a continuing program of research and development in crew safety and survival. New proposals might be introduced at later dates on the basis of these programs. No additional legislative authority is required for introduction of any of the equipment and procedures that would be proposed.

Vessel Operating and Design Criteria

The potential for a major marine incident always exists and U.S. Coast Guard records of reportable vessel casualties have been reviewed. A reportable vessel casualty involves damage affecting seaworthiness of a vessel, stranding or grounding, or material property damage in excess of $1,500. A reportable personal accident involves loss of life or incapacitation for a period in excess of 72 hours. Due to reporting procedures, the records for U.S. vessels are more complete than for foreign vessels. During the period from FY 1963 to FY 1976, a total of 111 vessel casualties were reported occurring on the Great Lakes and involving a collision with ice or

ice fields. Of the total, 61 involved cargo (freight vessels) and 20 involved tank ships. The remaining were split among other types of vessels, including one foreign tanker and two foreign freight vessels. The most important information obtained from the review regarding the need for regulation is that in the following categories no incidents are indicated:

a. Incidents of pollution
b. Vessels total loss
c. Deaths
d. Injured or incapacitated for 72 hours
e. Monetary damage to cargo
f. Monetary damage to property.

The Coast Guard draws its vessel hull strength and powering requirements from the American Bureau of Shipping "Rules for Building and Classing Steel Vessels". These "rules" also offer eight various classifications for operation in ice. The ice class rules cover hull strengthening, increased power, strengthened rudders and steering gears, special arrangements for sea chests to prevent freezeup, and special materials and designs for propellers. However, vessels meeting any of the ice classes are not considered satisfactory for independent operation in ice, i.e. without an icebreaker. Within the confines of these rules, it is the responsibility of the owner to determine which ice class is most suitable for his intended service.

Although this classification option is available to the owners, they are not required to make any ice classifications for their ships presently operating in winter conditions on the Great Lakes. It is noteworthy that lowest class ABS .cebreaker class C requires:

a. Shellplating on the ice belt to be increased 25%,

b. Increased strength of fore and after peak framing,

c. Intermediate frames added from stem to a point where maximum beam occurs,

d. A 25% increase in the strength of the rudder stock,

e. A special arrangement of the sea chest to minimize freezing,

f. Increased minimum horsepower, and

g. Increased strength of reduction gears and propellers.

Other winterizing modifications have already been addressed by the Coast Guard either in present or in proposed regulations, some of which are still being drafted. Most of the proposed regulations address new lifesaving equipment for protection of the crew under extreme conditions (46 CFR 92.20-50 requires "adequate" heating and accommodation spaces).

The Coast Guard has no visibility standards. Adequate visibility is required for all vessels, but the actual "adequacy" of it is left to the individual Master's interpretation. The Coast Guard is conducting a study to determine what factors are involved in the setting of visibility standards, as well as the development of the standards. Further, the Coast Guard charges the Master with the ultimate safety in the operation of his vessel. Statistics seem to indicate that the masters are doing a good job.

The above comments would suggest that no new regulations are necessary, and based on studies of vessel damage caused by ice since 1963, the Coast Guard does not feel new regulations relative to vessel construction are required at this time. However, a number of the vessels currently operating in ice are not designed to break ice,

and the potential for vessel casualties due to ice does exist and should increase as traffic levels increase. The need for ice strengthening exists in order for the Master to utilize all available power without a high risk of causing vessel damage. This reluctance to use full power due to the risk of hull damage is a major contributing factor in the large number of icebreakers required. Regulations for the strengthening of hulls, reduction gears, rudder stocks, and propellers may be required in the future. Several high powered vessels, which now operate in ice routinely as a result of the Demonstration Program, have received some hull strengthening. Otherwise, the limited number of icebreakers available may necessitate restricting operation of vessels in ice.

The problem of ships becoming stuck while operating in heavy ice conditions was shown to be a real one during the winter of 1978-1979, when instances of ships becoming entrapped outside Conneaut Harbor in Lake Erie and in the Livingstone Channel in the Lower Detroit River were reported. The possibility of such occurrences is raised in Appendix A in relation to the problem of piling ice at various locations. At certain times during severe winters, when ice and wind conditions are right, ice piles may develop to the extent that navigation may be interrupted for periods of time at specific locations. The use of ice booms at locations described in this Appendix would substantially prevent such a development within harbors and along connecting channels.

According to statistics provided by the U.S. Coast Guard, 34 Merchant vessels sustained ice damages during the 1978-79 winter navigation season, totalling $914,000. Eight Coast Guard vessels were damaged by ice during the same period, costs totalling $441,000.

Salvage Operations

The problem of salvage under ice conditions could be resolved by the same procedures used in removal of stranded or wrecked vessels

during the normal shipping season. The preferred course of action is for the owners themselves to make arrangements in securing the release of the vessel. If the owners and underwriters abandon the vessel and cargo to the U.S. Government, then it becomes the Corps of Engineers responsibility to remove the wreck (though the owners and underwriters are still liable for Government cost). In this instance, depending on the urgency of the case, the salvage operation can either be conducted by the Corps of Engineers or contracted out.

The alternative to extending established recovery operation procedures into the winter season is to negotiate open-ended contracts with qualified and well equipped salvage and towing contractors on the Great Lakes. Contractors would be paid to maintain a salvage vessel, complete with operating crew and certain minimum salvage gear, in a state of readiness at designated locations. Should experience gained in the Winter Navigation Program indicate that a quicker than normal response is needed for stranded or wrecked vessel cases, then this alternative may be found useful. Otherwise, it is recommended that customary procedures for salvage/recovery operations be followed. Experience under the Demonstration Program has not shown a need for a salvage vessel on standby.

Search and Rescue Requirements

The introduction of winter navigation on the Great Lakes will produce a need for surface and air capability to respond to incidents involving major vessels year-round. During winter months the only vessels capable of rendering assistance would be icebreakers. All-weather aircraft are also required for more rapid assistance needs. These aircraft resources are presently operating in the Great Lakes. Fulfillment of icebreaker requirements as previously outlined would inherently provide vessel search and rescue capabilities sufficient to meet the needs of merchant vessels operating in the winter. The

Coast Guard's ongoing aircraft replacement program will continue to provide the Coast Guard air stations at Chicago, Illinois; and Detroit and Traverse City, Michigan, with adequate all-weather aircraft to respond to winter search and rescue requirements.

Oil/Hazardous Substance Contingency Plans

Since there cannot be an absolute guarantee that it could not happen, the potential for an oil spill occurring during an extended season program does exist. For a number of reasons, that potential is lower in stable ice conditions and higher during spring breakup when the ice is moving downstream in rivers and bays near rivers. Under the various circumstances which could occur during a spill, the containment and clean-up operations could be either less difficult or more difficult than similar operations taking place during warmer weather.

Although the U.S. waters of the Great Lakes have never experienced a catastrophic winter related oil spill exceeding 100,000 gallons and no vessel related spills of significance have occurred during winter operations, a spill could be locally devastating to fisheries and wildlife.

The U.S. Coast Guard has developed a number of excellent contingency plans for spill clean-up and containment. Response time has been reduced to a few hours and good equipment is available. However, based on comments received on the Draft Report, Environmental Impact Statement, and the numerous public workshops and meetings, it appears that the public and agencies with the primary mission of protecting natural resources strongly desire further improvement of the ability to handle oil or toxic material spills. These agencies and the public have highlighted potential problems and the situation dictates that technology, contingency plans and equipment continue to be improved to afford better protection for

water quality and fish and wildlife resources which are essential to the health and economic well being of much of the population of the Great Lakes Basin. These resources form the basis of a multi-billion dollar tourist and recreation industry. Therefore, continued improvement of technology, technology transfer contingency plans and equipment is warranted and is proposed under the Environmental Plan of Action to afford the level of protection desired by the public.

The Coast Guard is charged with providing the Federal pre-designated on-scene coordinator in the coastal regions and the Great Lakes. This official has complete responsibility for on-scene actions to mitigate, contain, or otherwise assure the clean-up of oil spills. There are nine such officials spread throughout the Great Lakes. Personnel trained specifically in the handling of oil spills are available in each sub-region.

Under the National Contingency Plan for dealing with spill situations, regional response teams are mandated to advise and assist the on-scene coordinator. Primary Federal agencies on the teams include the Coast Guard, Environmental Protection Agency, Army Corps of Engineers, Department of Interior Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration, with state and local governments also well represented. The national strike force team for the Atlantic region, armed with the most sophisticated containment, transfer, and clean-up equipment, can be operating in the Great Lakes four hours after notification.

Besides the National Contingency Plan, a Great Lakes Region Contingency Plan, sub-regional plans throughout the Great Lakes, and a joint United States-Canada Contingency Plan, for occasions when waters in both countries are endangered, are all in existence and operative. These mechanisms have proven successful at times of emergency in the past.

As for the financing of cleanup operations, the cost is to be borne primarily by the owner of the facility which spilled the material. Financial responsibility is, however, limited. If cleanup costs exceed this limit, a "super fund" established by the Congress is tapped for the remaining costs. Legislation is under review which would increase the financial liability of the owner to avoid excessive depletion of the Coast Guard's funds.

These related considerations also would merit attention:

a. Proper clothing for response personnel and providing adequate shelter from the elements.

b. Handling and transporting standard and nonstandard response equipment under extreme weather conditions.

c. Staging areas which may require snow or ice removal.

d. Removing and disposing of oil contaminated ice (utilizing locally available clam scoop shovels, hopper barges, etc.).

e. Locally available steam generators and portable heaters for melting ice and heating solidified oil, in addition to locating pumps capable of moving extremely viscous liquids.

Vessel Waste Discharge

Blackwater

Blackwater is defined as human body wastes collected from urinals and toilets onboard commercial vessels. A study was conducted and a report prepared for Maritime Administration and the Corps of Engineers, to assess the effects of navigation season extension on blackwater waste disposal generated onboard Great Lakes Commercial vessels.

This report examines: (1) shoreside facilities for sewage disposal, (2) shipboard waste treatment units, (3) environmental effects of blackwater, (4) economic impact of legislation on ship operations.

Regulation of the discharge of blackwater from commercial vessels is based on the Federal Pollution Control Act of 1972. The Act states, in part:

a. the Coast Guard and the Administrator of EPA shall develop standards for marine sanitation devices (MSD's) and establish a time schedule for compliance.

b. Coast Guard certification is required for MSDs.

c. both new and existing vessels must comply with Federal regulations (treatment of blackwater) by January 30, 1980.

The Clean Water Act of 1977 further amends this law; the Act redefines vessel "sewage" to include graywater wastes and defines treatment of sewage to a minimum of secondary treatment. In addition, individual states bordering the lakes can be granted "no-discharge" zones in Great Lakes waters.

Shoreside facilities are required for sewage which is held onboard ships. Three methods of disposal are found in ports: tank trucks, discharge risers, and waste collection vessels. Tank trucks are widely available, but are limited by their volume capacity. Discharge risers are dockside permanent sewerline openings, and while expensive to install, have no volume limit. Waste collection vessels are rare, and have limited capacity. The ultimate destination of all vessel sewage is a wastewater treatment facility. Use of all three

sewage disposal methods has been minimal due to lack of demand and insufficient regulations. No serious problems with utilizing shoreside facilities have been encountered under winter navigation conditions and none are expected.

Most ports surveyed do not have adequate facilities to accept retained wastes, and many ports have none. By 1980, direct discharge of untreated sewage by vessels will be illegal, and an increase in demand for facilities will occur. An extended season on the Great Lakes should have no impact on the need for sewage disposal facilities in either numbers, size, or location.

A study of shipboard facilities for blackwater disposal concludes the following: (1) no treatment (33%), (2) treatment by maceration and disinfection with overboard discharge (34%), (3) retention onboard until reaching port (13%), (4) physical-chemical MSD treatment (18%).

Vessel devices used to collect and adequately dispose of wastes are called marine sanitation devices (MSD's). MSD's are of three types. Type I MSD's macerate and chlorinate vessel waste prior to discharge into receiving waters. Type II MSD's utilize physical-chemical and biological treatment. Type III MSD's are incineration units and retention systems, which allow no overboard discharge.

The present technology of shipboard treatment is sufficient to meet present environmental objectives, and navigation season extension would have little effect on shipboard MSD's.

In assessing the environmental impacts of treated sewage, the following parameters are considered: total phosphorus (TP), biochemical oxygen demand (BOD's), suspended solids (SS), residual chlorine and chlorinated organics. The discharge of untreated blackwater directly overboard would have local adverse and short-term effects upon daily and winter loadings in harbors, embayments, and during periods of ice cover in offshore waters. Short-term effects are dependent upon mixing properties of receiving waters, ice cover in offshore waters would reduce dispersion rates. Compared to other sources of loadings (industrial, municipal, etc.), annual loadings from vessels during an extended season were found to comprise less than 0.1% of the combined loadings from all sources. No long-term adverse effects from additional loadings of treated blackwater wastes of commercial vessels are anticipated as a result of extended season.

The economic impact of blackwater treatment and disposal on commercial vessels depends to a large extent on the regulations ultimately in effect. As previously stated, by 1980, Federal law requires blackwater wastes from ships to be either treated before discharge or held, and states may petition for "no-discharge" status. Ship operators must purchase and install one of the following: (1) physical-chemical or biological treatment unit, (2) holding tank, or (3) incineration unit. Biological treatment units average around \$35,000; holding tanks average \$50,000. In general, the economic penalty incurred by ship owners due to the addition of a sewage holding tank is not substantial, and should not be considered a major detriment to economic vessel operation during a normal or an extended season. It should be pointed out that these economic impacts would be a result of the passage of Pollution Control and Clean Water legislation, not extended season navigation.

. Graywater

The term graywater refers to vessel wastewaters collected from galley, laundry, shower, sinks and other miscellaneous drains. Graywater is not human sewage. A study was conducted and a report prepared for Maritime Administration and the Corps of Engineers, to assess the effects of winter navigation on the Great Lakes on vessel graywater waste disposal.

The report examines: (1) characterization of graywater and relevant legislation, (2) shipboard treatment systems, (3) environmental impacts, (4) shoreside disposal facilities, and (5) technical and economic effects of graywater treatment and retention.

Legislation pertinent to graywater includes an existing agreement with Canada and the Clean Water Act of 1977. Agreement with Canada precludes wastewater from being discharged by vessels into waters of the Great Lakes in deleterious amounts or concentrations. The Clean Water Act states:

a. in the future, "sewage" will be redefined, for Great Lakes vessels only, to include graywater.

b. the administrator of EPA shall, with respect to commercial vessels on the Great Lakes, establish standards that will require at a minimum the equivalent of secondary treatment.

c. graywater as defined by this Act excludes laundry waste.

A large percentage of vessels operating on the Great Lakes discharge graywater directly overboard without treatment. However, most vessels in the planning or construction stages plan treatment in

anticipation of graywater legislation. Vessel devices used to collect and adequately dispose of wastes are called marine sanitation devices (MSD's). The three types of MSD's are described in the previous Section on Blackwater.

In assessing the environmental impacts of graywater wastes, the following parameters are considered: total phosphorus (TP), suspended solids (SS), and biochemical oxygen demand (BOD's). The environmental effects of graywater discharge relate to the mixing and dispersion properties of the respective receiving waters, and the content of the graywater itself.

The discharge of untreated graywater directly overboard would have the effect of reducing dissolved oxygen of surface waters and increasing turbidity within the immediate vicinity of a vessel's discharge in harbors and ice-covered lakes and channels. Graywater loadings during ice cover may impact upon sensitive coastal environments and harbors due to lower rates of dispersion and mixing. Mixing action of waves and currents in offshore waters is usually sufficient to prevent localized, short-term or long-term impacts from the loadings.

It is estimated that vessel discharge of pollutants (both normal and extended navigation season) comprise less than 1% of total annual loadings to harbors, from all sources. Long-term effects, therefore, are considered minor with respect to impacts from other sources for both existing navigation season and the extended season.

For a discussion of shoreside wastewater facilities, see the previous section on Blackwater.

A majority of ships on the Great Lakes have the capability to treat or retain blackwater wastes. Pursuant to the Clean Water Act of 1977, the requirement for treatment and retention of graywater will have impacts on both new and existing vessels. Retention of graywater wastes for all Great Lakes vessels does not appear to be feasible due to: high cost of installation, large amount of space required for holding tanks, and the effect of same on vessel trim and draft. In general, ecomomic impacts of the requirements to treat graywater upon existing treatment systems will be the requirement to upgrade existing MSD's to handle graywater, and the costs of purchase and installation of larger units to handle all waste. MSD's which are designed to accept blackwater (human waste) are usually not adequate to treat or retain additional loading of graywater.

Other Discharges

Vessels unavoidably produce several types of pollutants which must be disposed of in some manner. These types include blackwater and graywater discussed above, and in addition: bilge waste, ballast water, solid waste and air pollutants.

Bilge waste, not presently regulated by legislation, consists of oil and oil-contaminated water and is intentionally discharged from the bilge (lowest inner part of a ship's hull). Leakage from equipment, piping or tanks, repair or maintenance of equipment is collected by drainage to the bilge area. Rates of bilge water generation vary considerably with each vessel, with older ships generating approximately 2,600 gallons per hour. Newer ships, less than 20 years old, generate half that amount.

Ballast waste is water which has been placed in an unloaded or lightly loaded ship for the purpose of stability. Once in port,

tremendous quantities are discharged. The amount varies with each type of vessel and its operation, and an average volume discharged from Great Lakes ore and bulk carriers is 2,300,000 gallons per port visit. This waste generally contains less than 100 parts per million (ppm) oil during initial pumping, and is not considered a significant source of pollution.

Solid waste consisting of paper, wood, glass, metals and plastics is also generated onboard ships. This refuse is regularly disposed of during port visits.

Air pollutants are emissions from ships' stacks and contribute to the pollution of the Great Lakes environment. Carbon monoxide, hydrocarbons, nitrogen oxides, sulphur, and particles are discharged into the atmosphere. Emissions vary considerably with fuel and engine type and size. The Federal Clean Air Act sets forth National Ambient Air Quality Standards, defining maximum allowable ambient concentrations for pollutants.

Implementation of the proposed navigation season extension plan, including construction and equipment operations, could alter the pattern of atmospheric loading temporarily on a local basis. However, the impacts of navigation season extension are not presently perceived to significantly alter the air quality of the Great Lakes region.

Environmental Plan of Action

The Environmental Plan of Action (EPOA) is an environmental program which includes procedures and methodology for environmental baseline data collection, monitoring, evaluation, and impact assessment needed for a comprehensive evaluation of the extended navigation season program. The cost of implementing the EPOA is shown in the cost tables for the recommended plan.

Pilot Access

Pilots are normally required for foreign vessels in the system, but not on lake freighters. To allow winter pilot transfer operations at Detour, Michigan, at the mouth of the St. Marys River, the existing transfer boat would have to be replaced by a new icebreaking tug. The tug would be 50 feet long and have 700 horsepower. Additionally, it would have to be equipped with window defrosting, space heating, and a heated deck to allow for safe movement.

On the Detroit River, near the Ambassador Bridge, the mail boat currently used to transfer pilots during the open water season would have to be replaced by an icebreaking tug to permit pilot transfers in the winter. The same capabilities to deal with window and deck icing, mentioned above, would be required on the Detroit River transfer tug.

On the St. Lawrence River at Cape Vincent, N.Y., there is a pilot transfer point (see Figure B-54). The pilots are transferred by two boats, both of which are only capable of non-winter operation. To allow winter operation, both boats would have to be replaced by new icebreaking tugs. The tugs would be 50 feet long and have 700 horsepower each. Additionally, they would have to be equipped with appropriate window defrosting, space heating, and heated deck to allow for safe movement.

Another alternative at this location would be to move the pilot transfer point from Cape Vincent, New York, down the river to Clayton, New York. The distance from shore to a meeting point with ships would be considerably reduced at Clayton and there would also be less problems with wind-blown ice piling up along the shoreline.

The major drawback would be that new mooring and office facilities would have to be constructed at Clayton. Questions concerning territorial overlap between open lake pilots and river pilots would need to be answered as well.

Environmental impacts could result from icebreaking by the transfer tugs and the use of larger berthing facilities that would be necessary as a consequence of winter pilot transfer at all three locations.

Vessel Captain/Pilot Training

In order to enhance the capabilities of masters operating during the extended navigation season, a comprehensive training program would be undertaken by industry, labor, and appropriate Federal agencies. In addition to a formal training phase, including films, manuals, charts, etc., primary emphasis would be placed on progressive on-the-job training. To gain maximum benefit from previous winter navigation experience, an information exchange program would be organized, highlighted by observation trips on vessels sailing in ice conditions.

Harbors

Icebreaking

It is anticipated that some harbors will require icebreaking assistance within the harbor itself. This icebreaking assistance would be rendered by commercial harbor tugs on an "as-needed" basis. Costs in connection with commercial tug icebreaking assistance would be borne by the ship owners and/or port authorities. Those harbors for which commercial icebreaking services are recommended are as follows: Silver Bay, Minnesota; Green Bay, Wisconsin; Marquette,

Muskegon, Escanaba, Ludington, Saginaw, Alpena, and Monroe, Michigan; Toledo and Huron, Ohio. Additionally, high horse-power commercial icebreaking tugs are anticipated to be needed at Duluth-Superior, Minnesota-Wisconsin; Ashland, Wisconsin; Sandusky, Ohio; and Buffalo, New York.

Although tugs would cause less turbulence than icebreakers, sediment movement may be more critical in harbors due to the polluted nature of many harbor bottoms. While environmental concerns are similar to those expressed under the Lakes-Connecting Channels-St. Lawrence River Icebreaking Requirements section of this appendix, impacts may differ.

In Duluth-Superior Harbor, as the winter season progresses, the thickness of the channel mush ice could become so difficult that vessels could stall. To clear the channel of this type of ice, a large wide beam mush ice clearing barge and towing vessel, possibly the buoyant-screw type ice tractor, would be constructed. This barge and towing vessel would reduce the amount of mush ice by sweeping the channel and pushing the ice to each side.

Ice Control Structures

Due to the shifting wind conditions on the Great Lakes and the tendency for lake ice to be wind-driven into harbor entrances, it is anticipated that it will be necessary to modify/reorient harbor entrances using floating log ice booms. A typ [illegible] ,oor or open lake ice boom is shown on Figure B-28. The harbors where harbor entrance modification is recommended are as follows:

Indiana Harbor, Indiana	Figure B-27
Muskegon, Michigan	Figure B-31
Saginaw, Michigan	Figure B-36

Ludington, Michigan	Figure B-32
Huron, Ohio	Figure B-45
Lorain, Ohio	Figure B-46
Cleveland, Ohio	Figure B-47
Ashtabula, Ohio	Figure B-48
Conneaut, Ohio	Figure B-49

Current and sedimentation patterns may tend to change as a result of ice control structures. There may be additional impacts to valuable fish and wildlife habitats as a result of ice boom placement operations, including the dredging necessary for some ice boom anchors.

Air Bubbler Systems

Air bubbler systems help keep surface ice thinned or melted, thus making ship passage easier. Detailed studies indicate that air bubbler systems may be needed in the inner harbors primarily along the docks (see Figure B-5 for a typical dock bubbler) and berthing areas in the turning basins. The harbors where air bubbler systems are recommended are as follows:

Duluth-Superior, Minnesota-Wisconsin	Figure B-4
Ashland, Wisconsin	Figure B-6
Marquette, Michigan	Figure B-8
Escanaba, Michigan	Figure B-22
Alpena, Michigan	Figure B-35
Monroe, Michigan	Figure B-42
Calumet Harbor, Illinois	Figure B-26
Sandusky, Ohio	Figure B-44
Huron, Ohio	Figure B-45

Aids to Navigation

Traditionally, all lighted buoys and radar reflector equipped unlighted buoys are withdrawn during late November and early December to prevent damage and/or loss of the aid during the winter. Some of these buoys were replaced with unlighted buoys not equipped with radar reflectors. These winter markers would barely be adequate at best and represent a significant reduction in effectiveness. Buoys are also subject to being submerged or carried off station by moving ice. Consequently, the reliability of floating aids marking channels is reduced, and vessel personnel are often times uncertain as to their exact position within the channel. The probability of grounding under these conditions is increased because the aids may be off station or under ice. Therefore, the U.S. Coast Guard has recommended the installation of fixed navigation light structures at critical locations. These navigation aids which are recommended in conjunction with winter navigation at specific harbors are located as follows: Duluth-Superior, Minnesota-Wisconsin - six fixed navigation lights; Green Bay, Wisconsin - four fixed navigation lights; Saginaw Bay, Michigan - two fixed navigation lights; Alpena, Michigan - one navigation light; Toledo, Ohio - one fixed navigation light.

DESIGN AND COSTS

Costs for the recommended plan are based on October 1979 price levels and include U.S. costs only and are shown on the Table of Phased First Investment/Annual Cost by Activity -Recommended Plan (Table B-7). All cost estimates include engineering, design, and supervision and administration of construction, based on similar cost relationships for recent projects. As part of the engineering and design effort for plan activities, exclusive of the Environmental Plan of Action, funds up to an amount of $2 million could be utilized for cultural and social studies.

TABLE B-7

PHASED FIRST/INVESTMENT/ANNUAL COST BY ACTIVI

Activity	Agency	Useful Life (Yrs.)	Const. Period (Yrs.)	Est. Quantity (Each)	CAPITAL COSTS Const. Cost ($1,000)	Engrg. & Des. Cost ($1,000)
ICEBREAKING	USCG					
Lakes Superior, Huron & Michigan						
Type B Icebreaker		50	2	2	90,000	4,500
Type C Icebreaker		40	1	10	25,000	1,250
St. Clair & Detroit Rivers & Lake Erie						
Type B		50	2	2	90,000	4,500
Type C		40	1	6	15,000	750
Lake Ontario & St. Lawrence River						
Type C		40	1	4	10,000	500
ICEBREAKER MOORING IMPROVEMENTS	USCG					
Lakes Superior, Huron & Michigan						
Type B		40	2	2	3,977	318
Type C - with Dredging		40	1	6	4,173	334
Type C - without Dredging		40	1	3	225	18
St. Clair & Detroit Rivers & Lake Erie						
Type B		40	2	2	3,977	318
Type C - with Dredging		40	1	4	2,782	223
Type C - without Dredging		40	1	2	150	12
Lake Ontario & St. Lawrence River						
Type C - with dredging		40	1	2	1,391	111
Type C - without dredging		40	1	2	150	12
VESSEL TRAFFIC CONTROL FOR	USCG					
Prevention of collision ramming & grounding						
Lakes Superior, Huron & Michigan		20	1	1	331	27
St. Clair & Detroit Rivers & Lake Erie		20	1	1	495	40
Convoying & Icebreaking						
Lakes Superior, Huron & Michigan		20	1	1	10	1
ICE DATA COLLECTION/ DISSEMINATION SYSTEMS	USCG					
Lakes Superior, Huron & Michigan		50	1	1	475	38
St. Clair & Detroit Rivers & Lake Erie		50	1	1	15	1
AIDS TO NAVIGATION	USCG					
Lakes Superior, Huron & Michigan		50	1	10	5,153	412
St. Clair & Detroit Rivers & Lake Erie	USCG	50	1	4	4,638	371
St. Lawrence River	SLSDC	20	1	14	1,920	154

(1)Present worth of capital cost.

(2)Includes interest during construction.

TABLE B-7

NT/ANNUAL COST BY ACTIVITY - RECOMMENDED PLAN

CAPITAL COSTS							
nst. ost ,000)	Engrg. & Des. Cost ($1,000)	Superv. and Admin. Cost ($1,000)	(1) First Cost ($1,000)	Total Investment Cost (2) ($1,000)	Annual Interest and Amortization Cost-$1,000	Annual Operation & Maintenance Cost-$1,000	Total Annual Cost ($1,000)
,000	4,500	4,725	60,605	63,424	4,668	2,130	6,798
,000	1,250	1,313	19,348	19,348	1,424	2,450	3,874
,000	4,500	4,725	60,604	63,423	4,668	2,130	6,798
,000	750	788	11,609	11,609	854	1,470	2,324
,000	500	525	7,739	7,739	570	980	1,550
3,977	318	344	3,170	3,318	244	--	244
,173	334	361	3,425	3,425	252	--	252
,225	18	19	184	184	14	--	14
3,977	318	344	3,170	3,318	244	--	244
2,782	223	240	2,285	2,285	168	--	168
150	12	13	121	121	9	--	9
1,391	111	120	1,143	1,143	84	--	84
150	12	13	121	121	9	--	9
331	27	29	333	333	25	--	25
495	40	43	498	498	37	334	371
10	1	1	10	10	1	11[illegible]	119
475	38	41	352	352	26	248	274
15	1	1	11	11	1	12	13
5,153	412	445	3,882	3,882	286	3	289
4,638	371	401	3,494	3,494	257	2	259
1,920	154	166	1,931	1,931	142	117	259

2

PHASED FIRST/INVESTMENT/ANNUAL COST BY ACTIVITY

					CAPITAL COSTS		
Activity	Agency	Useful Life (Yrs.)	Const. Period (Yrs.)	Est. Quantity (Each)	Const. Cost ($1,000)	Engrg. & Des. Cost ($1,000)	Super Admin ($1
ICE CONTROL STRUCTURES							
Soo Harbor Ice Boom	CORPS	25	1	1	464	37	
Soo Harbor Ice Stabilization	CORPS	50	1	1	243	19	
St. Clair River Ice Boom	CORPS	25	1	1	1,087	87	
Detroit River Ice Boom	CORPS	25	1	1	896	72	
St. Lawrence River Ice Boom - International Section	SLSDC	25	1	11	6,069	485	
AIR BUBBLER SYSTEMS	CORPS						
St. Marys River		10	1	6	1,132	113	
LOCK MODIFICATIONS							
Soo Locks - Lock & pier walls, gates, entrance channels & equipment improvement	CORPS	20	1	-	8,906	712	
Eisenhower Lock - Lock & pier walls, gates, entrance channels & equipment improvement	SLSDC	20	1	-	13,059	1,045	1
Shell Lock - Lock & pier walls, gates, entrance channels & equipment improvement	SLSDC	20	1	-	1,529	122	
DREDGING							
St. Marys River - Middle Neebish Channel	CORPS	50	2	1	75,732	3,029	4
COMPENSATING WORKS	CORPS						
St. Clair River		50	2	1	5,081	406	
Detroit River		50	2	1	19,094	1,528	1
SHORELINE & SHORE STRUCTURE PROTECTION							
St. Marys River -							
Shoreline Protection or Compensation	CORPS	15	1	4.8 mi.	1,571	126	
Shore Structure Compensation	CORPS	--	-	--	--	--	
St. Clair River -							
Shoreline Protection or Compensation	CORPS	15	1	0.8 mi.	246	20	
Shore Structure Compensation	CORPS	--	-	--	--	--	
Detroit River -							
Shoreline Protection or Compensation	CORPS	15	1	0.8 mi.	252	20	
Shore Structure Compensation	CORPS	--	-	--	--	--	
St. Lawrence River -							
Shoreline Protection or Compensation	SLSDC	15	1	3.2 mi.	1,061	85	
Shore Structure Compensation	SLSDC	--	-	--	--	--	
ISLAND TRANSPORTATION ASSISTANCE							
St. Lawrence River - Grindstone Island	SLSDC	20	2	1	1,007	81	
St. Marys River - Additional Ferry Operation Cost	CORPS	--	-	2	--	--	

(1) Present worth of capital cost.

(2) Includes interest during construction.

TABLE B-7

T/ANNUAL COST BY ACTIVITY - RECOMMENDED PLAN

CAPITAL COSTS							
st. st 000)	Engrg. & Des. Cost ($1,000)	Superv. and Admin. Cost ($1,000)	(1) First Cost ($1,000)	Total Investment Cost (2) ($1,000)	Annual Interest and Amortization Cost-$1,000	Annual Operation & Maintenance Cost-$1,000	Total Annual Cost ($1,000)
464	37	40	382	382	28	87	115
243	19	21	168	168	12	--	12
087	87	94	894	894	66	43	109
896	72	77	739	739	54	41	95
069	485	524	4,998	4,998	368	217	585
132	113	100	1,824	1,824	134	122	256
906	712	769	8,633	8,633	635	500	1,135
,059	1,045	1,128	12,639	12,659	932	485	1,417
,529	122	132	1,482	1,482	109	256	365
,732	3,029	4,726	53,310	55,791	4,107	174	4,281
,081	406	439	3,455	3,616	266	59	325
,094	1,528	1,650	12,989	13,593	1,001	146	1,147
1,571	126	136	1,893	1,893	139	37	176
--	--	--	160	160	12	--	12
246	20	21	297	297	22	5	27
--	--	--	370	370	27	-	27
252	20	22	304	304	22	5	27
--	--	--	0	0	0	-	0
1,061	85	92	1,279	1,279	94	25	119
--	--	--	678	678	50	--	50
1,007	81	87	844	883	65	32	97
--	--	--	--	--	--	12	12

2

PHASED FIRST/INVESTMENT/ANNUAL COST BY AC

Activity	Agency	Useful Life (Yrs.)	Const. Period (Yrs.)	Est. Quantity (Each)	CAPITAL COST Const. Cost ($1,000)	Engrg. & Des. Cost ($1,000)
WATER LEVEL MONITORING	CORPS					
Data Collection/Dissemination						
St. Clair & Detroit Rivers		50	-	-	52	4
Water Level Gages						
St. Marys River		20	1	-	151	12
ENVIRONMENTAL PLAN OF ACTION (STUDIES)	INTERIOR/ CORPS					
Lakes Superior, Huron, & Michigan & St. Marys River		--	-	-	--	57,816
St. Clair & Detroit Rivers & Lakes St. Clair & Erie		--	-	-	-	47,751
Lake Ontario & St. Lawrence River		--	-	-	--	21,003
PILOT ACCESS						
DeTour, Michigan	NONFED	20	2	1	719	58
Detroit, Michigan	NONFED	20	2	1	719	58
Cape Vincent, New York	NONFED	20	2	1	1,438	115
ICE & WEATHER FORECASTS	NOAA					
Lakes Superior, Huron & Michigan		50	1	1	65	5
CHANNELS & LAKES SUBTOTALS					400,435	148,699
SILVER BAY, MINNESOTA	NONFED					
Icebreaking Tug		--	-	1	--	--
DULUTH - SUPERIOR						
Aids to Navigation	USCG	50	1	6	765	61
Bubblers (8-1000')	NONFED	10	1	8	965	96
Bubblers (2-2000')	NONFED	10	1	2	368	37
Bubblers (1-3000')	NONFED	10	1	1	273	27
Bubblers (2-4000')	NONFED	10	1	2	685	68
High Power Icebreaking Tug	NONFED	--	-	1	--	--
Channel Clearing Craft	NONFED	--	-	1	--	--
ASHLAND, WISCONSIN	NONFED					
Bubblers (1000')		10	1	1	121	12
High Power Icebreaking Tug		--	-	1	--	--
MARQUETTE, MICHIGAN	NONFED					
Bubblers (1000')		10	1	1	121	12
Icebreaking Tug		--	-	1	--	--

(1)Present worth of capital cost.

(2)Includes interest during construction.

TABLE B-7

NT/ANNUAL COST BY ACTIVITY - RECOMMENDED PLAN

CAPITAL COSTS onst. Cost (1,000)	Engrg. & Des. Cost ($1,000)	Superv. and Admin. Cost ($1,000)	First Cost (1) ($1,000)	Total Investment Cost (2) ($1,000)	Annual Interest and Amortization Cost-$1,000	Annual Operation & Maintenance Cost-$1,000	Total Annual Cost ($1,000)
52	4	5	40	40	3	52	55
151	12	13	154	154	11	29	40
--	57,816	--	51,780	51,780	3,811	--	3,811
--	47,751	--	42,766	42,766	3,148	--	3,148
--	21,003	--	18,810	18,810	1,385	--	1,385
719	58	62	674	705	52	28	80
719	58	62	674	705	52	28	80
1,438	115	124	1,348	1,411	104	57	161
65	5	6	48	48	4	244	248
00,435	148,699	24,987	407,687	417,031	30,696	12,678	43,374
--	--	--	--	--	--	25	25
765	61	66	569	569	42	2	44
965	96	85	1,555	1,555	114	473	587
368	37	32	594	594	44	139	183
273	27	24	439	439	32	86	118
685	68	60	1,103	1,103	81	199	280
--	--	--	--	--	--	417	417
--	--	--	--	--	--	161	161
121	12	11	194	194	14	59	73
--	--	--	--	--	--	522	522
121	12	11	194	194	14	59	73
--	--	--	--	--	--	71	71

TABLE B-7

PHASED FIRST/INVESTMENT/ANNUAL COST BY ACTI

Activity	Agency	Useful Life (Yrs.)	Const. Period (Yrs.)	Est. Quantity (Each)	CAPITAL COSTS Const. Cost ($1,000)	Engrg. & Des. Cost ($1,000)
ESCANABA, MICHIGAN	NONFED					
Bubblers (1-1000')		10	1	1	121	12
Bubblers (4-4000')		10	1	4	1,368	137
Icebreaking Tug		--	-	1	--	--
GREEN BAY, WISCONSIN						
Navigation Lights	USCG	50	1	4	2,783	223
Icebreaking Tug	NONFED	--	-	1	--	--
CALUMET, ILLINOIS	NONFED					
Bubblers (2-1000')		10	1	2	241	24
Bubblers (1-2000')		10	1	1	185	18
Bubblers (1-4000')		10	1	1	342	34
INDIANA HARBOR, INDIANA	CORPS					
Ice Boom (4000')		25	1	1	1,142	91
MUSKEGON, MICHIGAN	CORPS					
Ice Boom (7600')		25	1	1	2,179	174
Icebreaking Tug	NONFED	--	-	1	--	--
LUDINGTON, MICHIGAN						
Ice Boom (8000')	CORPS	25	1	1	2,286	183
Icebreaking Tug	NONFED	--	-	1	--	--
ALPENA, MICHIGAN						
Navigation Lights	USCG	50	1	1	695	56
Bubblers (2-1000')	NONFED	10	1	2	241	24
Icebreaking Tug	NONFED	--	-	1	--	--
SAGINAW, MICHIGAN						
Navigation Lights	USCG	50	1	2	1,391	111
Ice Boom (10,000')	CORPS	25	1	1	2,621	210
Icebreaking Tug	NONFED	--	-	1	--	--
MONROE, MICHIGAN	NONFED					
Bubblers (2-2000')		10	1	2	368	37
Icebreaking Tug		--	-	1	--	--
TOLEDO, OHIO						
Aid to Navigation	USCG	50	1	1	1,163	93
Icebreaking Tug	NONFED	--	-	1	--	--

(1)Present worth of capital cost.

(2)Includes interest during construction.

TABLE B-7

ENT/ANNUAL COST BY ACTIVITY - RECOMMENDED PLAN

CAPITAL COSTS							
Const. Cost ($1,000)	Engrg. & Des. Cost ($1,000)	Superv. and Admin. Cost ($1,000)	(1) First Cost ($1,000)	Total Investment Cost (2) ($1,000)	Annual Interest and Amortization Cost-$1,000	Annual Operation & Maintenance Cost-$1,000	Total Annual Cost ($1,000)
121	12	11	194	194	14	59	73
1,368	137	120	2,204	2,204	162	399	561
--	--	--	--	--	--	75	75
2,783	223	240	2,071	2,071	152	1	153
--	--	--	--	--	--	75	75
241	24	21	389	389	29	118	147
185	18	16	297	297	22	70	92
342	34	30	552	552	41	100	141
1,142	91	99	1,079	1,079	79	74	153
2,179	174	188	2,059	2,059	152	141	293
--	--	--	--	--	--	93	93
2,286	183	198	2,161	2,161	159	149	308
--	--	--	--	--	--	93	93
695	56	60	517	517	38	1	39
241	24	21	388	388	29	118	147
--	--	--	--	--	--	93	93
1,391	111	120	1,035	1,035	76	1	77
2,621	210	226	2,477	2,477	182	186	368
--	--	--	--	--	--	93	93
368	37	32	553	553	41	139	180
--	--	--	--	--	--	93	93
1,163	93	100	790	790	58	1	59
--	--	--	--	--	--	75	75

2

TABLE B-7

PHASED FIRST/INVESTMENT/ANNUAL COST BY ACTIV

Activity	Agency	Useful Life (Yrs.)	Const. Period (Yrs.)	Est. Quantity (Each)	CAPITAL COSTS Const. Cost ($1,000)	Engrg. & Des. Cost ($1,000)
SANDUSKY, OHIO	NONFED					
Bubblers (1000')		10	1	1	121	12
High Power Icebreaking Tug		--	-	1	--	--
HURON, OHIO						
Bubblers (2-1000')	NONFED	10	1	2	241	24
Ice Boom (1600')	CORPS	10	1	1	500	40
Icebreaking Tug	NONFED	--	-	1	--	--
LORAIN, OHIO	CORPS					
Ice Boom (6800')		10	1	1	1,963	157
CLEVELAND, OHIO	CORPS					
Ice Boom (4800')		10	1	1	1,427	114
ASHTABULA, OHIO	CORPS					
Ice Boom (7200')		10	1	1	2,071	166
CONNEAUT, OHIO	CORPS					
Ice Boom (7600')		10	1	1	2,178	174
BUFFALO, NEW YORK	NONFED					
High Power Icebreaking Tug		--	-	1	--	--
HARBORS SUBTOTAL					28,925	2,427
GRAND TOTAL					429,360	151,126

(1)Present worth of capital cost.

(2)Includes interest during construction.

TABLE B-7

T/ANNUAL COST BY ACTIVITY - RECOMMENDED PLAN

CAPITAL COSTS							
st. ost 000)	Engrg. & Des. Cost ($1,000)	Superv. and Admin. Cost ($1,000)	(1) First Cost ($1,000)	Total Investment Cost (2) ($1,000)	Annual Interest and Amortization Cost-$1,000	Annual Operation & Maintenance Cost-$1,000	Total Annual Cost ($1,000)
121	12	11	181	181	13	59	72
--	--	--	--	--	--	522	522
241	24	21	362	362	27	118	145
500	40	43	736	736	54	30	84
--	--	--	--	--	--	93	93
,963	157	170	2,890	2,890	213	126	339
1,427	114	123	2,100	2,100	155	89	244
2,071	166	179	3,050	3,050	225	135	360
2,178	174	188	3,205	3,205	236	140	376
--	--	--	--	--	--	417	417
28,925	2,427	2,506	33,938	33,938	2,498	6,189	8,687
29,360	151,126	27,493	441,625	450,969	33,194	18,867	52,061

2

The first costs for all the improvements shown in the following table include both capital costs and replacement costs. Replacement costs for each particular improvement were discounted back to present worth at 7-1/8% based on the useful life of the improvement. For example, if a certain improvement has a useful life of 10 years, then it was assumed that replacement costs would accrue in the 10th, 20th, 30th, and 40th year of the 50-year project life. This stream of replacement costs was then discounted back to present worth and combined with capital cost and interest during construction to derive the total investment cost of the improvement. Interest during construction was accrued to items of two or more years construction time.

Estimates of annual costs were based on an economic life of 50 years. The estimated total average annual costs include interest, repayment of the principal (amortization), and operation and maintenance charges. Operation and maintenance charges for the Great Lakes-St. Lawrence Seaway System include floating plant, such as icebreakers and icebreaking tugs, mooring facilities for floating plant, ice booms, air bubblers, navigation locks, aids to navigation, dredged channels, and compensating works.

The first costs, total investment costs, and annual costs for the recommended plan shown in Table B-6 have been time phased in accordance with the Phased Implementation sequence discussed earlier in this Appendix. The base date for all costs is 1987, the same as that of the benefits.

In deriving the United States costs on the Great Lakes boundary waters, two assumptions were made: (1) for the St. Lawrence River, the U.S. would pay for 100% of all improvements within U.S. territorial area as well as 50% of the total cost of facilities bridging the international boundary. Conversely, it is assumed that Canada would pay for 100% of all improvements within its own

territorial boundaries, as well as 50% of the total cost of facilities bridging the international boundary; and (2) for the St. Clair River-Lake St. Clair-Detroit River System, the U.S. would pay 50% of all ice control structures and compensating works required within the system. It should be noted that this U.S./Canada cost split is an initial assumption and is subject to negotiations between the U.S. and Canadian governments.

PLAN IMPLEMENTATION

Survey Report Approval Process

The Final Survey Report is defined as the best report that can be prepared with the given time and money constraints. It defines the problems, needs, and opportunities, draws conclusions, and makes recommendations within the limits of available data. This report will be made available to the public for review and comment.

A final environmental statement has been prepared and is presented with the Main Report.

The current completion schedule for the survey report is as follows:

Activity	Completion Date
Division Engineer Notice and Submittal to Office of Chief of Engineers and Board of Engineers for Rivers and Harbors	December 1979/ January 1980

Following the issuance of the Division Engineer's public notice of the report completion, the survey report would be reviewed by the Board of Engineers for Rivers and Harbors and the Office of the Chief of Engineers.

The Chief of Engineers would transmit the survey report to the Governors of the affected States and to interested Federal agencies for formal review and comment.

Following the above State and interagency review, the final report of the Chief of Engineers would be forwarded to the Secretary of the Army. Subsequent to seeking the comments of the Office of Management and Budget regarding the relationship of the project to the program of the President, the Secretary of the Army would forward the survey report to the Congress.

Congressional authorization of any recommended navigation improvements is required. This procedure includes appropriate review and hearings by the Public Works Committee.

If the project is authorized by the Congress, funds would be requested through the budgetary process.

If the Congress appropriates the necessary initial funds, formal assurances of any required local cooperation would be requested from non-Federal interests, prior to initiation of construction.

It is not possible to accurately estimate a schedule for the above steps at this time, although it is estimated that at least two years would be required before any authorization could be expected.

Phased Implementation

Although this study is being pursued with the objective of achieving a Single-Phase Construction Authorization for the entire Great Lakes-St. Lawrence Seaway System, it is currently planned that the project would be implemented in phases. This is due to current constraints such as the lack of an active co-participation agreement

with the Canadian Government. The proposed phases are illustrated in Plate B-1. Benefit-cost analyses for these are presented in Appendix D-Economics, Benefits and Costs. The alternative phases are:

Period of Extension

Alternative Phase	Lake Superior St. Marys River Lake Michigan Straits of Mackinac Lake Huron	St. Clair River Lake St. Clair Detroit River Lake Erie	Welland Canal Lake Ontario St. Lawrence River
(1)Base Condition	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1	Year-round	1 Apr - 31 Jan	1 Apr - 15 Dec
2	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3	Year-round	Year-round	1 Apr - 31 Dec
4	Year-round	Year-round	20 Mar - 31 Dec
5	Year-round	Year-round	7 Mar - 7 Jan
6	Year-round	Year-round	7 Feb - 7 Jan

(1)Base condition - March 1976 Interim Feasibility Report recommending extended season navigation on the upper four Great Lakes to 31 January (± 2 weeks) using only existing operational measures.

(2)This is the recommended plan.

To be done concurrently with the implementation, during the first 10-15 years of the advanced engineering and design, construction, and operations phases of the project, would be an Environmental Plan of Action. This plan of action would be designed to provide an adaptive method for determining the environmental feasibility of an extended navigation season program and to provide assurance that winter navigation would be conducted in an environmentally acceptable manner, with provisions made for accomplishing any necessary mitigative actions.

The Environmental Plan of Action is an integral part of the Adaptive Method described earlier in this appendix. The method would be completed in the post-authorization stage.

Programmatic Environmental Statement

The Environmental Impact Statement (EIS) is programmatic in nature, addressing the impacts of the entire program on a level of detail less precise than, but supportive of, the engineering studies. The programmatic EIS addresses the known and potential primary, secondary, and cumulative impacts of the program on a regional scale, and provides the program to determine and analyze the environmental data and information for the detailed follow-on EIS's.

For those areas where a need for information exists, an Environmental Plan of Action (EPOA) has been developed to provide for the remaining data considered necessary for a comprehensive evaluation of the authorized Winter Navigation Program.

Environmental Plan of Action (EPOA)

The EPOA, prepared by the U.S. Fish and Wildlife Service and the Corps of Engineers, has been integrated with the recommended engineering program to extend the navigation season. The EPOA provides for obtaining the remaining data and define the appropriate methodologies and assessments essential for understanding the environmental implication of the recommended program on the entire Great Lakes-St. Lawrence System. The EPOA lays out a plan for confirming environmental feasibility of the recommended program to be accomplished concurrently with the phased design, then construction, and then implementation of an authorized extended season program. Appendix E contains the EPOA.

Assuming Congressional authorization of a Federally assisted Winter Navigation Program, the project would then move into advance

engineering and design phases prior to construction and operation which is briefly described in the following paragraphs.

Post-authorization - Preconstruction Planning

The first step of the post-authorization process is advance engineering and design (AE&D), which consists of three phases: Phase I General Design Memorandum (GDM), Phase II GDM and Feature Design Memoranda, and preparation of Detailed Plans and Specifications. It is important to note that the post-authorization steps are standard courses of action taken for any authorized civil works project. Project design becomes progressively more detailed and finalized in each phase of the process. The adaptive method approach will have a significant role in each phase as described below.

Phase I GDM. The objective of the Phase I GDM Program--the reaffirmation or reformulation phase--is to bridge the gap between the time when a survey report is completed and authorized, and the initiation of detailed engineering and design of the authorized plan. During the authorization period, changes may occur that could affect the formulation of the authorized project plan and change the authorized plan significantly. The Phase I GDM study seeks to identify, assess, and evaluate changes in order that an affirmation of the authorized plan can be made in light of current conditions and criteria, or a "reformulation" of the authorized plan may be made where these changes are significant.

The adaptive method approach during this preconstruction phase includes: implementation of design-specific and systemic baseline environmental studies as indicated by the EPOA; and secondly, it would provide individual assessments of those activities significantly interacting with the environment, and, when necessary, provide environmental statements prior to construction/operation of the individual activity based on additional information provided through implementation of the EPOA. This approach will refine the detail and location of impacts identified in the programmatic EIS.

Individual environmental statements would be developed as appropriate for each of the project's separable elements, addressing site specific impacts at a level of detail equal to that of the engineering studies. The post-authorization EIS for each Phase I GDM will refine the breadth of impacts identified by the programmatic EIS as well as information gained through the baseline studies begun in this phase.

During the pre-construction phase, mathematical and physical models as well as vessel transit tests of the system are proposed for the International Section of the St. Lawrence River.

The design-specific environmental studies, begun during this phase, are being scheduled to be completed at least twelve months before completion of the Phase I GDM. This would, if necessary, provide for incorporation of changes to the authorized plan where such changes are significant.

Phase II GDM. After approval of the Phase I document, a Phase II General Design Memorandum Stage would be initiated. The Phase II document would be primarily a functional design document.

Activities under the adaptive method approach in this phase would continue to examine baseline studies conducted in Phase I. While no formal environmental impact report would normally be required other than archaeological reconnaissance as necessary, design details would be sensitive to specific environmental and social concerns surfaced after the last formal EIS (in Phase I GDM). Should the designs undergo significant change, new EIS's could be required.

After approval of the Phase II General Design Memorandum, specific project feature design memorandums would be prepared for each major element of the project. Each of the feature design

memorandums would, where practicable, include sufficient design data to establish the interrelationship between engineering, the environment, and other design aspects of the particular feature. Following this step, detailed plans and specifications would be prepared on the specific project feature to enable construction of the project. Site specific EIS's could be required for each specific feature, depending on the adequacy of previous statements.

Post-authorization - Construction/Operation

During the construction stages of the program, the emphasis of environmental effort would transform from establishing baseline conditions to monitoring of "with" project conditions. This monitoring effort would provide a means for determining whether or not the impact predictions were correct and no unacceptable adverse impacts are or would occur with continued operations. Subtle or cumulative impacts could be determined. Due to the flexible response to environmental concerns as part of the adaptive method, all actions during construction and operation stages would be sensitive to any adverse project induced changes identified by the monitoring effort.

The monitoring effort would continue in the operational phase and would culminate in the final evaluation or validation report. It is at this validation point that the overall project would be evaluated in light of project induced changes, a validation report prepared, and the report subsequently provided to the Congress for its information.

Summary

The adaptive method would provide the mechanism, in concert with the advanced engineering and design and construction and operation

phases of the project, for a sequence of information gathering, impact predictions, and monitoring to further evaluate and assess the validity of earlier impact predictions. Through the adaptive method, construction would not proceed until adequate environmental assessments and statements have been completed during the pre-construction phase. In addition, the adaptive response mechanism would provide, when and where necessary, for modifying construction/operational activities to reduce or eliminate unacceptable impacts identified by proposed monitoring programs. Results of the adaptive method would be culminated in a validation report and provided to the Congress.

To implement the project, a joint United States-Canadian Board has been recommended to oversee: engineering/planning, construction, environmental monitoring and operations to insure that implementation be a coordinated effort.

ATTACHMENT 1 TO APPENDIX B

EVALUATION OF ALTERNATIVES
AND
SELECTION OF PROPOSED PLAN

Colored sheets are provided to distinguish this attachment from the rest of the report.

This attachment presents the plan formulation discussion and evaluation of alternatives used in the selection of the study proposed plan. These pages have been extracted from the March 1976 Interim Feasibility Report (Volume 1 - Main Report) on the Great Lakes - St. Lawrence Seaway Navigation Season Extension Survey Study - House Document No. 96-181. Procedures used in developing this analysis remain valid, though refinements made in the final formulation of the recommended plan for this Final Survey Report have resulted in the outdating of certain details in this attachment.

POSSIBLE SOLUTIONS

During the preliminary phase of this study, alternative solutions were developed for consideration and evaluation. To help insure that the best overall plan is developed, the range of alternative plans was developed based on different sets of formulation criteria as displayed in the previous paragraphs. This task provides for developing alternative resource management systems that address the planning objectives of the study.

The alternative plans developed are:

a. Traditional Navigation Season. This alternative describes traditional winter operation of commercial navigation on the Great Lakes-

St. Lawrence Seaway System prior to the initiation of the Demonstration Program portion of the winter navigation study in 1971. Prior to 1971 vessel operators ceased operations during the winter months from about mid-December to until early April depending upon ice and weather conditions. Exact dates vary depending upon actual conditions from year to year.

b. Fixed Navigation Season: Same as Traditional Navigation Season alternative, however, a fixed navigation season would be imposed on the St. Marys River at the Lock facilities between 1 April and 15 December. Traditional navigation would occur in the remainder of the system.

c. Extended Navigation Season: This alternative addresses the extension of the navigation season in the entire Great Lakes-St. Lawrence Seaway System to as much as 12 months or year-round.

Further detailed description of each of these three alternatives, together with their contributions to the planning objectives of the study, are displayed in the following section entitled "Solutions Considered Further." Each of these alternatives is considered a feasible solution and, consequently, is considered for further analysis.

SOLUTIONS CONSIDERED FURTHER

TRADITIONAL NAVIGATION SEASON

Basically this alternative, which is non-structural, describes the traditional winter operation on the Great Lakes-St. Lawrence Seaway System (i.e. base condition). Prior to 1967, commercial navigation on the entire system generally occurred between 1 April and 15 December (i.e. normal 8-1/2 month shipping season). Any pre- or post-season extension generally was, and still is, curtailed by such items as weather; severe ice conditions in the harbors, locks, lakes, and connecting channels; increased marine insurance costs; inability of vessels to operate in ice conditions because of low power and lack of winterized vessel quarters; and ice booms across navigation channels in the St. Lawrence River.

Generally, under existing conditions, general cargo movement is moved by alternative modes of transportation during the winter months (shipping companies consider stockpiling of general cargo uneconomical because of its relatively high value per ton as compared to bulk cargo) whereas bulk commodities are stockpiled during the winter months because of their relatively low value per ton as compared to general cargo (shippers consider it more economical to stockpile bulk commodities, such as iron ore, grain and stone products, during the winter months than ship the commodities by alternative modes of transportation). This type of operation is expected to continue under this alternative.

There has been traditionally for years intralake traffic on the Lakes, primarily Lake Michigan and western Lake Erie, and also along the St. Clair-Detroit Rivers during the winter months for transport of principally petroleum, coal, stone products, and iron ore. This traffic is expected to continue under this alternative.

Table D-1 displays a summary of these commodities as collected by telephone surveys and from vessel receiving reports provided by the shipping companies for the past four years from 1971 to 1975 (data prior to 1971 is not available for cargo movement after 15 December). This data is considered to be indicative of the expected commodity movement in the future under this alternative.

TABLE D-1

NORMAL INTRALAKE WINTER TRAFFIC (1971-75)

(1,000 Tons)

Commodity	71-72	72-73	73-74*	74-75*
Iron Ore	39.0	951.9	1,024.3	1,376.2
Grain	-	-	119.0	119.8
Coal	1,064.7	563.4	1,534.7	1,724.9
Stone	140.5	464.0	1,096.6	1,078.1
Petroleum Products	366.6	727.4	958.2	812.6
Other	34.4	227.2	798.3	369.7
TOTAL	1,645.2	2,933.9	5,531.1	5,481.3

* - These years are based on more comprehensive shipping data and are more reflective of normal winter traffic than figures shown for 71-72 and 72-73.

Because of the physical characteristics of Lake Michigan, little stable ice forms on the lake proper except in the most northerly reaches (Green Bay, Straits of Mackinac), along the shoreline and in harbor areas. Lake Erie, because of its shallowness, generally freezes over; however, ice conditions are not such in the western end to impede vessel movement. If there are any problems, in either Lakes Michigan or Erie, U.S. Coast Guard icebreaking assistance is available under their own operational support policies (i.e. to meet reasonable demands of commerce).

The Great Lakes connecting channels between Lakes Superior and Huron, and Lakes Michigan and Huron, namely the St. Marys River and the Straits of Mackinac, respectively, freeze over entirely during the winter months and are difficult to navigate without icebreaking assistance from the U.S. Coast Guard. Ice thicknesses up to several feet in both these areas, tight turns in the St. Marys River, lack of winterized navigation aids, low power capabilities of vessels, and increased risks reflected in increased marine insurance costs have in the past discouraged shipping during the winter months in these areas. The following chart displays the number of years, out of the last 31 years, that the air temperature has been below and above the average mean temperature for the Sault Ste. Marie, Michigan area.

Number of Years
Historical Average Air Temperature (Dec.-Apr.)
Sault Ste. Marie, Michigan

	Below	Average	Above
1944-54	0	9	1
1955-64	2	7	1
1965-75	3	7	1

The locks at the St. Marys Falls Canal at Sault Ste. Marie, Michigan have traditionally been open to shippers only to meet the reasonable demands of commerce to the extent that weather and ice conditions permit. This type of operation is expected to continue.

Vessel movement during the winter months in the St. Clair-Lake St. Clair-Detroit Rivers System has in the past been minimal with the exception of stone movement from Lake Huron into the St. Clair-Detroit Rivers, coal movement to Detroit from Toledo, and oil movement between Sarnia, Ontario and Detroit. This movement is expected to continue. The St. Clair River does not generally freeze over; however, it is occasionally laden with broken ice floating into it from Lake Huron in addition to ice generated within its boundaries. This broken ice has a tendency to jam in the constricted areas of the river, in particular at the lower end of the river at the headwaters of Lake St. Clair. Lake St. Clair generally freezes over in its entirety and is a prime location for winter recreation activities such as icefishing. The Detroit River is relatively ice free except during thaws or the spring ice breakup period where ice from Lake St. Clair floes into the river.

Any shipping from the St. Clair River to Lake Huron, or vice versa, has been discouraged during the winter months because of the fragility of the natural ice bridge at the headwaters of the St. Clair River. Whenever this ice bridge collapses, whether it be by natural forces (wind) or by vessel movement through it, broken ice is permitted to floe into the river and has on occasion created flooding in the lower St. Clair River due to ice jamming in constricted areas and retarding the flow in the river. This situation is expected to continue.

As stated before, vessel movement has traditionally occurred in the western end of Lake Erie. The eastern end of the Lake near Buffalo, New York, is a natural constriction and prevailing east-west winds pile large quantities of ice in this area making shipping very difficult, particularly in the spring. Therefore, ship movement is expected to continue principally on the western end of the Lake.

The opening and closing dates of the Welland Canal and its locks have been consistent with the corresponding dates of the locks on the St. Lawrence River. Vessel movement through the Welland Canal in the past, generally at the end of the 8-1/2 month normal shipping season, goes into or through the Seaway, or goes into Lake Ontario ports for winter lay-up.

In summary, under the Traditional Navigation Season alternative there is no planned season extension for the entire system; however, intralake movement on Lakes Michigan and Erie and movement on the St. Clair-Detroit Rivers is expected to continue throughout the winter months. This plan would continue to enable low cost bulk commodity movement into the winter months. Vessel movement in the upper four Lakes, including the St. Marys River and Straits of Mackinac, would still be at the discretion of the shipping companies and largely dependent upon the severity of ice and winter conditions in the connecting channels as well as in the ports of origin and destination.

The Welland Canal and its locks and the St. Marys Falls Canal Locks are expected to remain open to shippers only to meet the reasonable demands of commerce to the extent that weather and ice conditions permit.

Navigation on the St. Lawrence River ceases when in the judgement of the Seaway operating entities (St. Lawrence Seaway Development Corporation-U.S., St. Lawrence Seaway Authority of Canada) ice and weather conditions preclude safe and efficient navigation on the St. Lawrence River. It is a long-standing U.S. policy and specific U.S./Canada agreements that operation of power works, and specifically the ice booms installed yearly on the river by the power entities, do not interfere with navigation.

On the St. Lawrence River, no change in the current operating plan would be contemplated under this alternative. Since the St. Lawrence River would be closed during the winter, enhancement of year-round overseas trade is not foreseen.

This plan would only contribute to national economic benefits consistent with the existing growth trend of the region. Existing operational measures would continue to be available in the winter, such as icebreaking assistance and operation of the lock facilities at Sault Ste. Marie, Michigan, based on the severity of winter and reasonable demands of commerce, but not at a level required for an extended navigation season program.

Since this plan does not have any structural improvements or mitigation measures, adverse environmental and social effects on shore structures, shore erosion, island transportation and power production, particularly in the St. Marys and St. Clair Rivers would continue to occur. Contributions to these effects would be from natural conditions (i.e. thawing, winds) as well as commercial vessel movement in ice-covered waters.

Estimated costs and benefits, at December 1975 price levels, are as follows:

Investment Cost:	No estimate
Annual Costs:	No estimate
Annual Benefits	No estimate
Benefits/Costs	No estimate

FIXED NAVIGATION SEASON

The second alternative considered, also non-structural, involves the same type of operation as the Traditional Navigation Season alternative. However, a fixed navigation season would be imposed on the St. Marys River at the lock facilities between 1 April and 15 December. In this plan a notice would be distributed to shipping interests stating that the Soo Locks would remain open no later than 15 December and would reopen no earlier than 1 April. Earlier closing and later opening dates would be dependent upon ice and weather conditions. Traditional navigation would occur in the remainder of the system as described under the "Traditional Navigation Season".

This alternative, which would be applied only to the St. Marys River, is considered to be the most environmentally acceptable for that area because it would tend to minimize potential damage, other than that caused by natural phenomena. This alternative would also minimize the effects upon power production and recreational activities in these ice-covered constricted areas as a result of vessel movement. In addition, this plan would reduce the existing growth trend of the region by limiting the utilization of existing facilities and services.

Installation of the ice booms on the St. Lawrence River is expected to continue as described under the Traditional Navigation System alternative. Operation of the Welland Canal is also expected to be the same as under the Traditional Navigation Season alternative. As in the Traditional Navigation Season alternative, enhancement of year-round overseas trade is not foreseen under this plan.

Estimated costs and benefits, at December 1975 price levels, are as follows:

Investment Cost:	No estimate
Annual Cost	No estimate
Annual Benefits	No estimate
Benefits/Costs	No estimate

EXTENDED NAVIGATION SEASON

The third alternative considered, which includes both non-structural and structural measures, involves the extension of the navigation season in the entire Great Lakes-St. Lawrence Seaway System to as much as 12 months or year-round constrained only by economic, environmental, engineering and social effects. For study purposes three periods of navigation season extension were evaluated. These are (1) extend to 31 January, (2) extend to 28 February, and (3) extend to year-round.

The Demonstration Program, from 1971 to 1974, showed vessel movement through the St. Marys River, which is considered to be one of the most difficult connecting channels to navigate during the winter, to 29 January, 1 February, 8 February and 7 February, respectively. Virtually no permanent structural improvements were used. The 1975 operation in the St. Marys River and upper Great Lakes went to a record year-round extension due to above normal winter conditions.

Navigation season extension can provide and enhance national economic and environmental benefits and would contribute to the social well-being of the entire 19-state Great Lakes region.

There would be three primary economic benefits derived from winter navigation. First, there will be considerable savings from transportation rate differentials comparing overland and waterborne transport modes; second, savings from reduced stockpiling, handling and real estate inventory costs; and third, savings from better use of the existing vessel fleet

Increases in overall regional property values could be expected. Business and industrial activity would be stimulated. Seasonal use of locks, harbor and port facilities would be reduced. Production, income and employment would be stimulated.

Improvements, such as ice control devices, in the St. Marys and St. Clair Rivers would enhance power production by minimizing naturally

occurring ice jams in constricted reaches of the river. Evaluation of the St. Lawrence River will be in subsequent interim reports. Operation of ferry transportation in the connecting channels would also be enhanced by these devices.

During the initial phases of implementation of this plan, nearly maximum use of existing facilities would be realized with a minimum of capital expenditures.

This plan, through the use of improved shore and on-board navigational aids, ice weather collection and dissemination systems, winterized vessel quarters and improved safety and survival techniques would enhance the safety and welfare of the vessel crews plying the ice-covered waters.

In addition, this plan would, through extended season navigation in the St. Lawrence River, enhance year-round overseas trade of general cargo which would, in turn, enhance production, income and employment in the Great Lakes hinterland region, in addition to that stimulated by intralake bulk cargo movement.

Estimated costs and benefits, at December 1975 price levels are as follows:

Great Lakes-St. Lawrence Seaway
Extended Season*

	31 January	28 February	Year-round
Investment Cost:	$264,838,000	$329,523,000	$329,542,000
**Annual Costs:	$ 23,447,000	$ 30,766,000	$ 33,808,000
Annual Benefits	$ 78,100,000	$176,300,000	$200,900,000
Benefits/Costs	3.3	5.7	5.9

*See Appendix V

** - Total U.S. Costs w/o Lock Twinning

Prior to the initiation of the Demonstration Program, many possible conceptual non-structural and structural measures to extend the naviga-

tion were considered and presented in a Preliminary Feasibility Report on Navigation Season Extension in the Great Lakes-St. Lawrence Seaway System which was prepared in 1969. These are listed in the follow-[illegible] tion entitled "Possible Measures."

Through the advent of the Demonstration Program authorized in 1970 and results of actual field and detailed scope studies conducted under this program, since 1971, specific items were able to be tested and more specifically identified, and as a result were considered further as feasible means of extending the navigation season. These are listed under the following section entitled "Measures Considered Further."

Possible Measures

The possible measures for extending the navigation season are in four main categories; ice information, ice navigation, ice control and management, and associated problems attributed to extended season navigation.

Ice Information

The following solutions to the problem areas of ice information were considered:

a. Expansion of the existing Coast Guard Ice Navigation Center to provide daily reports and ice and weather forecasts to vessel operators on weather and ice conditions.
b. Development of short and long-term forecast techniques for ice formation and growth on the Great Lakes and long-term freezeup and breakup on the St. Lawrence River.
c. Gather information using conventional aircraft equipped with side-looking airborne radar; infrared scanning of ice cover; conventional photographic mapping of the ice extent and topography; and satellite imagery.
d. Monitoring of ice conditions by physical measurement of ice thicknesses and ice type at selected locations.

Ice Navigation

The following solutions were considered for the problems of ice navigation:

a. Use of conventional icebreakers.
b. Use ice plow to push ice to side of commercial shipping track.
c. Apply strengthening to hull of commercial vessels to resist ice.
d. Equip lake cargo vessels with icebreaking bows.
e. Increase lake vessels icebreaking capability with upward breaking bow plus a bulb which would add buoyancy to the bow.
f. Use fixed or floating ice buoys (lighted and unlighted).
g. Relay vessel track information to the users, upon request by the local Coast Guard units.
h. Precise electronic navigation systems.
i. Radar Transponder Beacons (RACONs).
j. "Follow-the-Wire" navigation aid system.
k. Channel dredging.
l. Automated vessel reporting system.
m. Use gates or provide gaps in ice booms to allow passage of vessels.
n. Provide mooring improvements at selected harbors to accommodate icebreaking vessels.

Ice Management and Control

The following solutions were considered for the problems of ice management and control:

a. Air bubbler systems in channels and harbors to convey warmer water from the bottom to the surface to reduce or retard ice formation.
b. Thermal check valves to provide heat transfer from the warmer water on the bottom to the ice-cover on top.
c. Cribs to maintain ice as insulation.
d. Ice booms to maintain ice as insulation.

e. Stabilized, biodegradable foam as ice retardant.

f. Flow diversion to maintain velocities sufficient to prevent ice formation.

g. Geothermal heat.

h. Solar heat.

i. Dusting of ice to facilitate icebreaking.

j. Ice barge with saws or water jets to cut through ice.

k. Propeller unit to erode ice in harbors.

l. Ice sluices to divert ice in channels.

m. Restrain ice from locks by floating box beams.

n. Use sector, rolling, vertical lift, or tainter gates in locks.

o. Lock facility improvements such as safety boom and gate engine pit enclosures, air bubblers in gate recesses, modifications to existing floating plants for winter lock maintenance, and vertical lock wall ice removing heating of the lock walls.

p. Inclose and heat downstream side of lower mitre gates.

q. Use banks of heating lamps on lock gates.

r. Apply anti-icing coating to lock walls or use a steam cleaning system.

s. Divert warm discharges from thermal power facilities to maintain ice-free channels.

t. Use of a channel clearing barge unit for removal of ice from navigation channel.

u. Dredging of channels in high velocity reaches to reduce velocity and assist in establishing an ice cover with the use of an ice boom.

Associated Problems Attributed to Extended Season Navigation

The following solutions were considered for those problems which are caused entirely or in part by winter navigation:

a. Provide shoreline bank protection.

b. Provide shore structure protection.

c. Check structural soundness of shore structures when reviewing

required permits for work adjacent to navigable U.S. waters.

d. Limit vessel speed through channels to minimize shore structure damage.

e. Provide water level gauge systems to warn of possible flooding and ice jams.

f. Modify car ferries for operating in ice to maintain island transportation.

g. Extend operation of Oil Pollution Strike Force under the U.S. Coast Guard.

h. Add additional search and rescue capability.

i. Provide vessel crews with special clothing for winter environment.

j. Close certain channels to maintain island transportation, (i.e. West Neebish Channel in St. Marys River).

k. Provide bubbler-flusher units at ferry landing docks.

Most Promising Measures

The most promising measures at this time are summarized under three categories for ease of reference: (1) operational measures, (2) information collection and dissemination systems, and (3) remedial measures. These measures were chosen upon an analysis of problems, identified to date, related to extending the navigation season on the entire system and are considered as means of mitigating or solving these problems. Actual field tests and evaluation and detailed studies to date done under the Demonstration Program were used to assist in the selection of these measures.

Further detailed analysis will continue to be conducted to assess the feasibility of each of the measures, specifically to application at selected sites, and will be presented in subsequent interim reports. A description of the analysis is addressed in the following section entitled "Further Investigation Required."

The type and location of these measures are displayed on Table D-2 in the following subsection entitled "Location of Most Promising Measures."

OPERATIONAL MEASURES

The following enabling measures are considered to be necessary operational measures:

Icebreaking Assistance

Icebreaking assistance in lakes, connecting channels, and harbors by vessels with icebreaking capability was found to be an effective way of aiding ice navigation of commercial vessels. This would also include use of a channel clearing craft in the St. Lawrence River to remove ice from the navigation channel.

Ice Control Devices

Ice control devices (e.g. floating log booms) to stabilize the ice-cover are effective means of managing ice. These devices, designed to permit navigation, would stabilize ice-covers and prevent subsequent ice jams downstream.

Navigation Aids

Navigation aids include ice buoys and radar transponder beacons (RACONs). Ice buoys were developed and tested under the Demonstration Program to withstand the rigorous ice environment, to maintain their position in ice, to be highly detectable by a ship's radar, to be readily detectable visually, and to be a valuable aid to a shipmaster in planning the approach to a turn in a channel. The RACON, which transmits a response to a ship's radar signal, enables large ranges of 8 to 16 miles and distinct coded identification of shore targets so equipped. RACONs have been demonstrated and used in trial locations and found very effective.

Precise Navigation System

The precise navigation system under consideration would be a short-

range electronic shipboard navigation aid to determine a ship's location, speed and a.titude. The system would be used in harbors, bays, and channels.

Air Bubbler Systems

Air bubblers in harbor channel areas, at docking and berthing areas, at tight turns in the connecting channels, and in lock facilities were considered for their ability to control ice formation and reduce ice thickness. Air bubblers were found to be an effective ice reducing means.

Lock Modifications

Lock modifications would include such items as safety boom and gate engine pit enclosures, vertical lock wall ice removal both manually and with the use of heat, air bubblers in gate recesses, and modifying existing floating plants for winter lock maintenance.

Dredging

Dredging improvements in the St. Lawrence River to reduce velocities in high velocity reaches to allow formation of an ice cover with the use of ice booms. Dredging areas in selected harbors to enable mooring of icebreaking vessels.

Mooring Improvements

Mooring improvements at selected harbors would be undertaken to accommodate U.S. Coast Guard icebreaking vessels.

INFORMATION COLLECTION AND DISSEMINATION SYSTEMS

The following items were considered the most promising information collection and dissemination systems:

Ice Navigation Center

The U.S. Coast Guard Ice Navigation Center at Cleveland, Ohio, would be expanded to collect, monitor and disseminate ice, weather and shipping data as advisories and forecasts.

Aerial Ice Reconnaissance

Aerial ice reconnaissance would be conducted throughout the entire system by Coast Guard medium-range aircraft equipped with appropriate sensors.

Automated Vessel Reporting System

The Automated Vessel Reporting System would monitor vessel passage itineraries and other information to provide current up-to-date advisories as to vessel movement by the U.S. Coast Guard icebreaking fleet.

Water Level Gauges

Water level gauges to provide a warning system of rising water levels in the event of downstream ice jams would be required to advise local authorities, shore residents and powerplant personnel of possible flooding.

REMEDIAL MEASURES

The following items were considered as possible actions to mitigate potentially adverse effects of extended season navigation:

Assistance to Ferry Transportation

Methods to allow island residents on the St. Marys River to maintain transportation to the mainland during the winter months were

considered. Plans would include closing the West Neebish Channel in the St. Marys River, and providing bubbler-flusher units at the ferry docks. Assistance to ferries operating in the St. Clair River would also be considered.

Powerplant Protection

Flood protection is contemplated to the Edison Sault Electric Company powerplant on the St. Marys River to minimize the risk of shutdown as a result of flooding caused by possible downstream ice jams.

Shore Erosion and Shore Structure Protection

Problems with shore erosion and shore structure damage along the connecting channels are recognized and were and will continue to be evaluated with regards to winter navigation. Areas on the St. Marys River have been identified, as well as on the St. Clair River; however, further detailed evaluation is needed, to include the St. Lawrence River.

Location of Most Promising Measures.

The entire system was analyzed, on a preliminary basis, as to the problems and requirements considered necessary to extend the navigation season in the following areas: (1) five Great Lakes, (2) Great Lakes connecting channels including the Welland Canal, (3) locks in the St. Marys River, Welland Canal and St. Lawrence River, (4) harbors in the entire system, and (5) the St. Lawrence River. Table D-2 displays those requirements considered, as discussed in the previous section, to extend the navigation season throughout the system.

Sources of information which were used to determine both the areas and the corresponding measures to extend the navigation season in these areas are as follows:

TABLE D-2

NAVIGATION SEASON EXTENSION

TYPE AND LOCATION OF ACTIVITIES

NOTES

A specified ■ for an entire river or lake system implies that the activity is available anywhere in the lake or river system, including harbors.

The type and location of activities presently anticipated as a minimum requirement to allow an extension of the navigation season is shown on this table. This table displays those activities which have been identified to date.

Location of Activity	Operational Elements								Information Collection Disseminat				Remed. Meas.		
	Icebreaking Assistance	Ice Control Devices	Navigation Aids	Precise Navigation System	Air Bubbler Systems	Lock Modifications	Dredging	Mooring Improvements	Ice Navigation Center Services	Aerial Reconnaissance	Automated Vessel Reporting System	Water Level Gauges	Assistance to Ferry Transportation	Powerplant Protection	Shore Erosion and Shore Struc. Protect.
LAKE SUPERIOR	■		■						■	■	■				
Duluth-Superior Harbor					■										
Silver Bay Harbor					■										
Taconite Harbor					■										
Two Harbors					■										
Presque Isle Harbor					■										
ST. MARYS RIVER	■		■	■					■	■	■	■			■
Whitefish Bay			■		■										
Soo Locks						■									
Sault Ste. Marie, Michigan														■	
Little Rapids Cut		■													
Sugar Island													■		
Middle Neebish Channel		■			■										
Lime Island Turn					■										
Pipe Island Turn		■			■										
Lime Island													■		
LAKE MICHIGAN	■								■	■	■				
Milwaukee Harbor								■							
Green Bay Harbor			■		■										
Muskegon Harbor		■													
Ludington Harbor		■													
STRAITS of Mackinac	■		■						■	■	■				
St. Ignace Harbor							■	■							

TABLE D-2 (continued)

NAVIGATION SEASON EXTENSION

TYPE AND LOCATION OF ACTIVITIES

NOTES

O A similar system presently exists on Lake Ontario and the St. Lawrence River.

** Activities entirely within Canadian boundaries (Note: these activites are not reflected in cost estimates)

Location of Activity	Operational Elements								Informatio Collection Disseminat				Remed. Meas.		
	Icebreaking Assistance	Ice Control Devices	Navigation Aids	Precise Navigation System	Air Bubbler Systems	Lock Modifications	Dredging	Mooring Improvements	Ice Navigation Center Services	Aerial Reconnaissance	Automated Vessel Reporting System	Water Level Gauges	Assistance to Ferry Transportation	Powerplant Protection	Shore Erosion and Shore Struc. Protect.
LAKE HURON (incl. Saginaw Bay)	—		—	—					—	—	—				
Saginaw River		—													
ST. CLAIR-DETROIT RIVERS SYSTEM	—		—	—					—	—	—	—			—
Port Huron		—													
LAKE ERIE	—		—						—	—	—				
Ashtabula Harbor		—													
Buffalo Harbor		—													
Lorain Harbor		—													
Conneaut Harbor		—													
Cleveland									—						
WELLAND CANAL						—					O				
LAKE ONTARIO	—		—					—	—	—	O				
ST. LAWRENCE RIVER	—		—	—				—	—	—	O				
Iroquois Lock						—									
Snell Lock						—									
Eisenhower Lock						—									
** Beauharnois Lock						—									
** Cote Ste. Catherine Lock						—									
** St. Lambert Lock						—									
** Beauharno's Canal Area		—													
St. Regis Island Area		—					—								
Ogden Island Area		—					—								
Ogdensburg-Prescott/Galop Island		—					—								

a. Tests and evaluation, and reports thereon, of measures demonstrated under the five year Demonstration Program (air bubblers in channels and harbors; vessel passage through an ice boom; navigation aids; precise navigation systems; Ice Navigation Center; aerial and ground reconnaissance; assistance to ferry transportation; shore erosion and shore structure damage surveillance; and safety and survival equipment).

b. Experience gained through five winters of actual vessel movement in the upper four Great Lakes during the Demonstration Program (ice-breaking assistance by the U.S. Coast Guard; commercial vessels using an on-board precise navigation system; commercial vessel movement through the locks at Sault Ste. Marie, Michigan, to as much as year-round (12 months) during the 1974-75 winter season; commercial vessels passing through air bubbler test sites; collection and dissemination of actual ice, weather and shipping data by the Ice Navigation Center).

c. Correspondence with Lake Carrier's Association, which represents shipping interests, as to requirements and measures their organization considers necessary in the St. Marys River.

d. System Plan for All-Year Navigation on the St. Lawrence River, published by the St. Lawrence Seaway Development Corporation, developed alternative system cost-effective plans to enable extended season navigation between Montreal, Quebec, and Lake Ontario. A summary report on this study is in Appendix IV.

e. Draft Report dated March 1974 on the Effects of Winter Navigation on Shore Erosion and Shore Structure Damage on the St. Marys River, Michigan, published by the Detroit District, U.S. Army Corps of Engineers.

f. Model study of the Little Rapids Cut area of the St. Marys River used to develop feasible solutions to problems related to winter navigation in the Little Rapids Cut area. A report, prepared by Acres American, Inc., Buffalo, New York, was prepared in December 1975.

g. Harbors (*) studies performed by the St. Paul and Chicago Districts, U.S. Army Corps of Engineers, and Arctec, Inc. of Columbia, Maryland for the Detroit and Buffalo Districts.

* - The harbors considered for analysis in this study were those which had projected (2005) extended season traffic greater than 100,000 tons per year. These estimates are currently being updated. All private and commercial harbors will be addressed in subsequent interim reports.

Table D-2 displays those harbors identified to date which were considered to need improvements to permit winter operation.

Least Promising Measures

Items addressed in section "Possible Measures" that are considered least promising at this time because of economic, engineering or environmental considerations or because results have not yet been completed under the Demonstration Program are as follows:

a. Using an ice plow to push ice to the side of the navigation vessel track was considered engineeringly unfeasible because of the massive amount of ice which would have to be moved as well as a lack of area, in some reaches, to contain the ice. It is important to note that it can be undesirable to winter navigation to try to keep ice out of the vessel track entirely because the resulting open water will only produce more ice.

b. Strengthening commercial vessels to operate in winter conditions by hull strengthening or by providing icebreaking bows is considered to be the responsibility of the vessel operator.

c. The Precise All Weather Navigation System requires further evaluation of such items as resolution and portability before it can be considered as a feasible navigation aid.

d. The "Follow-the-Wire" navigation aid system, considered for application in local areas such as the connecting channels, was considered only as a potential substitute to buoys and therefore was not considered further.

e. At this time enough is not known to propose the use of thermal ice suppression through the use of thermal check valves, geothermal heat, solar heat, and heated effluent from powerplants. A thermal ice suppression system demonstration project is in operation under the FY 76 Demonstration Program at Saginaw Bay, Michigan, to provide more insight into the use of thermal heat.

f. Ice control devices such as cribs were not considered feasible because of their inability to pass water. Because the Great Lakes-St. Lawrence Seaway system is along International boundaries, structures which could have a significant effect upon levels and flows in the system are not considered as a feasible solution when ice booms, which will allow the passage of water will perform the desired functions of controlling ice.

g. The use of ice retardants such as dusting or foam was not considered feasible because of the necessity to continually reapply the material to the ice cover because it looses its effectiveness when covered by blowing snow.

h. Areas have yet to be identified where the technique of flow diversion to suppress ice formation could be used. In addition, the same reasoning might apply as under (f) in regards to effects on levels and flows.

i. Mechanical devices such as water jets have not proven to be effective means of providing tracks in the ice cover for vessel passage.

j. Propeller units to erode ice are not considered feasible because of their inability to provide heat to the ice cover without

causing a significant amount of turbulence which is undesirable. In addition, such units would have a tendency to provide local open water areas which could result in more ice being generated.

k. Use of floating box beams to prevent ice from entering lock chambers, which is being pushed by vessels entering the lock is not considered feasible. Vessel speed and width (beam) as well as lock width, when compared to vessel beam has considerable effect upon the amount of ice pushed into a lock by a vessel. Because the ice is being pushed directly ahead of the vessel, there is no effective way to remove it. Opening of the lock gates may be a problem if the ice is deep enough behind the gate; however, with the aid of air bubblers in the gate recesses and fanning of the gates as they open, opening of the gates is considered feasible without further modification. If ice builds up too much above the locks, it is considered practicable to just lock the ice through rather than trying to retain the ice above the locks.

l. Operation of the mitre gates during the Demonstration Program has shown them practical and feasible and, therefore, the use of sector, rolling, vertical lift, or tainter gates is not considered proposed.

m. Heating of the downstream side of mitre gates has shown to be useful at the Soo Locks; however, any additional use of this technique is not contemplated at this time.

n. Heating lamps used at lock facilities are not considered to be feasible to remove ice buildup on large surfaces because of their fragility and maintenance problems.

o. Anti-coating devices have not yet been developed which are practical to apply to lock walls. Techniques are under investigation during FY 76 by the U.S. Army Cold Regions Research and Engineering Laboratory and results will be available in subsequent interim reports.

p. Vessel speed limits are established on the connecting channels

now, and changes to these limits are not contemplated at this time. Ice conditions generally will control vessel speed.

q. Ice control devices are being proposed upstream of ferry operating lanes to stabilize the ice cover and minimize the movement of ice into the ferry areas. Therefore, modification to car ferries to operate in ice conditions is not considered necessary.

r. Expansion of the Oil Pollution Strike Force and search and rescue capabilities of the Coast Guard beyond which is now available is not considered necessary. Existing facilities are considered adequate to handle extended season operation.

s. Provisions of special clothing for vessel crews on vessels operating in winter conditions is considered to be the responsibility of the vessel operator.

DEVELOPING PLANS

The three alternatives: (1) Traditional Navigation Season, (2) Fixed Navigation Season, and (3) Extended Navigation Season were further evaluated as to their relative impacts and contributions to the specific planning objectives of the study and the broad planning objectives of National Economic Development (NED) and Environmental Quality (EQ), and the associated accounts of Social Well-Being (SWB) and Regional Development (RD).

The evaluation process involved classifying each of the three alternatives as to the fulfillment of both the national and specific study planning objectives and assessing the relative adverse and beneficial merits of each alternative to arrive at a selected plan.

Comparative impacts and evaluation of the three alternatives are displayed in Table D-3 (Summary Comparison of Alternative Plans) and Table D-4, D-5 and D-6 (System of Accounts) for each alternative plan.

To continue the formulation process, it is necessary to designate the alternatives which best serve the range of broad national planning objectives and specific planning objectives of the study. As a minimum, the U.S. Army Corps of Engineers Policies and Procedures, the guidelines for this study, require that a national economic development (NED) plan and an environmental quality (EQ) plan be identified. Also for this study a non-structural (NS) plan is evaluated.

Using these plans, the overall formulation process leading to the selected plan consists of comparing the estimated conditions of each plan with the base conditions expected without the plan and determining the beneficial and adverse effects of each plan. Through this process, plan completeness is assured.

National Economic Development (NED) Plan

The NED plan addresses the planning objectives of the study while maximizing the net economic benefits. Therefore, using the economic data as displayed previously and in Tables D-3, D-4, D-5 and D-6, that plan which exhibits the maximum net economic benefits is the "Extended Navigation Season" plan. This plan consists of both non-structural and structural improvements to enable a permanent 50-year extension of the navigation season on the Great Lakes-St. Lawrence Seaway System.

Environmental Quality (EQ) Plan

The environmental quality plan, like the NED plan, addresses the range of planning objectives but emphasizes contributions to the preservation, maintenance, restoration and enhancement of the environmental quality of the Great Lakes-St. Lawrence Seaway System. Using the environmental data as displayed in Tables D-3, D-4, D-5 and D-6 and comparing each plan, that plan which exhibits the above stated contributions to the environment is the "Fixed Navigation Season" plan. This non-structural plan minimizes the effect on the environment due to vessel movement in ice-covered water by limiting navigation, through the Soo Locks to the period 1 April to 15 December.

Non-Structural (NS) Plan

The non-structural plan is one which addresses the range of planning objectives by emphasizing non-structural means. The "Traditional Navigation Season" plan is considered the non-structural plan. This plan describes the recent historical winter operation of commercial navigation on the Great Lakes-St. Lawrence Seaway System prior to the initiation of the Demonstration Program portion of the winter navigation study in 1971.

For comparison purposes, Table D-3 is provided displaying a detailed summary of each of the three alternatives for the reader. This table presents the significant planning considerations underlying each alternative plan, namely, plan description, significant impacts, contributions to the study planning objectives, contributions to the four national accounts - national economic development - environmental quality - social well being - regional development, and implementation responsibility.

TABLE D-3

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
1. PLAN DESCRIPTION	This non-structural plan involves the traditional winter operation of commercial navigation on the Great Lakes-St. Lawrence Seaway System. There is no planned season extension. Commercial bulk carriers movement confined essentially to upper four Great Lakes and more specifically intralake movement on Lakes Michigan and Erie, and movement on the St. Clair-Detroit Rivers from Lakes Huron and Erie. Principal commodities moved are iron ore, grain, coal, stone and petroleum. Lock facilities at Welland Canal and Sault Ste. Marie, Michigan would remain open only to meet reasonable demands of commerce to the extent that ice and weather conditions permit. Navigation on the St. Lawrence River would be closed to navigation in winter months.	This non-structural plan involves the same type of operation as the "Traditional Navigation Season" plan. However a fixed navigation season would be imposed on the St. Marys River at the lock facilities between 1 April and 15 December. Traditional navigation as described under Alternative 1, would occur in the remainder of the system.	This plan, which is both non-structural and structural, involves the extension of the navigation season on the entire Great Lakes-St. Lawrence Seaway System to as much as 12-months or year-round, constrained only by economic, environmental, engineering and social effects. For study purposes and evaluation, three periods of season extension were evaluated: (1) extend to 31 January (2) extend to 28 February (3) extend to year-round To achieve each of the stated dates, various levels of improvements are required at selected harbors, connecting channels, locks and the Lakes. Operational Measures Icebreaking Assistance Ice Control Devices Navigation Aids Precise Navigation Systems Air Bubbler Systems Lock Modifications Dredging Mooring Improvements Information Collection and Dissemination Systems Ice Navigation Center Aerial Ice Reconnaissance Automated Vessel Reporting System Water Level Gauges Remedial Measures Assistance to Ferry Transportation Powerplant Protection Shore Erosion and Shore Structure Protection

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
2. SIGNIFICANT IMPACTS			
A. Economic Effects			
Property values	Values will appreciate over time as economy of region gradually increases.	Somewhat less than 'Alternative 1' plan due to slower growth rate in the region.	Navigation improvements will cause additional increases in overall regional property values over that described in 'Alternative 1' plan. However, certain shoreline properties may decline in value due to damages sustained from vessels moving in ice (mitigation measures will be addressed in the subsequent interim reports.
Tax revenue	Normal increase to states, counties and cities in the region because of gradual growth in the region.	Somewhat less than 'Alternative 1' plan due to slower growth rate in the region.	Accelerated growth in region will cause an increase in revenues to states, counties and cities over that described in 'Alternative 1' plan.
Public facilities and services	Gradual increase in harbor facilities and related services to accomodate normal growth in the region.	Reduction in harbor facilities and related services over that required for 'Alternative 1' plan due to restricted navigation season.	Additional harbor facilities and related services will be required over that described in 'Alternative 1' plan in order to accomodate extended season navigation.
Employment/Labor force	No significant effect.	Slight decline in employment in region due to slower growth rate resulting from restricted navigation season.	Increase in employment in region due to increased growth rate resulting from extended season navigation.
Disruption of community growth	No significant effect.	Certain harbor communities would experience an increased migration of unemployed workers out of area during a restricted navigation season, thereby disrupting community growth.	Extended season navigation would reduce seasonal unemployment during the winter months in certain harbor communities, thus permitting more stable community growth.
Disruption of business and industrial activity	No significant effect.	Business and industrial activity would decline somewhat as a result of a restricted navigation season.	Business and industrial activity would increase as a result of extended season navigation, particularly in the commercial shipping industry and in those industries that are users of the region's bulk commodities.
Commercial navigation	Existing growth trend for commercial navigation on the entire system will continue.	A growth trend for commercial navigation would be somewhat less than that for the 'Alternative 1' plan.	An increase in commercial navigation over the 'Alternative 1' plan as the entire system becomes more competitive with alternative modes of transportation.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
B. Enviromental Effects			
Man-made Resources	Adverse effect to shore structures by vessels moving in ice-covered waters however. less effect than Alternative 3.	Reduces effect to shore structures and reduced wear on navigation structures in ice-covered waters.	Potential increased adverse effect to shore structures by vessels moving in ice-covered waters. Wear on navigation structures, namely locks. (Means to mitigate potential shore structure damage to be in subsequent interim reports
Natural Resources	See Effects - Water Quality, Air Pollution and Erosion-Sedimentation.	Reduce effect to environment during early winter months.	Same as 'Alternative 1' however extended over entire system. Damage to wetland communities in constricted channels by ice scouring. Short term damage to channel bottom from installation of ice boom anchors (in St. Marys and St. Clair River and St. Lawrence River), and dredging of mooring facilities for icebreakers. Long term damage to channel bottom from dredging channel in St. Lawrence River (Detailed assessment to be in suseqent interim reports.)
Air Pollution	Vessel smog extended into winter months in upper 4 Great Lake harbors open in winter (also connecting channels).	Reduce pollution level during early winter throughout system particularly in harbors and connecting channels.	Same as 'Alternative 1', however extended over entire system with greater frequency.
Water Quality	Danger from oil spills by accident of vessels moving in ice-covered waters.	Reduced danger from oil spills by accident of vessels moving in ice-covered waters.	Continued potential danger of oil spills by longer operation; however research and vessel construction would tend to reduce potential danger. Changes to local micro-climate in connecting channels and harbors expected. No large scale changes caused by air bubblers and possible resultant open-water. More dissolved oxygen in water.
Flooding	Expected continuance of flooding caused by ice jams (caused by vessel movement and natural conditions) and resultant damage in St. Marys and St. Clair Rivers.	Expected continuance of flooding caused by natural ice jams and resultant damage in St. Marys and St. Clair Rivers.	Minimize flooding potential, and resultant damages, by installation of ice control devices and water level warning systems in the St. Marys and St. Clair Rivers. (Further investigation required to identify problem areas in the St. Lawrence River).

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
B. Environmental Effects (cont'd)			
Erosion-Sedimentation & Shorelands	Expected continuance of natural shore erosion and sedimentation in constricted areas of connecting channels and lakes under ice conditions with possible additional effect depending upon length of the navigation season.	Same as 'Alternative 1' however without any possible additional effects from ship passage during the winter months.	Reduce potential shore erosion and sedimentation by shore protection (rip-rap) in the St. Marys River. (Further detailed investigation of possible shore erosion sites in the entire system, including the St. Lawrence River, is required). No significant effects by operation of air bubblers. Construction effects on sedimentation significant for dredging for short term (See Effect - Natural Resources). Expected recovery for long term.
Ice-cover Stability	Connecting channels, namely the St. Marys River, lower St. Clair River, and Lake St. Clair, are areas of concern. Vessel movement would create an unstable ice-cover in the immediate vicinity of the vessel track and could cause weakness of the ice-cover or cause ice to break away from the shoreline. (Straits of Mackinac and the St. Clair and Detroit Rivers are naturally unstable ice areas). Development of ice bridges in the St. Marys and St. Clair Rivers would be retarded. Potential effect upon animal migration in the St. Marys River.	Ice cover would not be disrupted by vessel movement. Movement of ice would be caused only by natural conditions.	Same as 'Alternative 1' except development of of natural ice bridges in the St. Marys River and St. Clair River would be enhanced by installation of floating log boom ice control devices. Also mass movement of ice would be retarded by installation of these devices at additional selected sites in the St. Marys and St. Lawrence River.
Fauna	Continued aeration of aquatic habitat in ice-covered waters by vessel tracks broken in ice. Potential danger to waterfowl by possible oil spills. No significant effect on migratory patterns of fish.	Stable ice-cover allowed to develop on St. Marys River to enable migration of animals across the river.	Same as 'Alternative 1', however with potential damage to fish spawning and nursing areas. (Detailed assessment required to evaluate impact of dredging in the St. Lawrence River upon fish migration).
Benthos	No significant effect.	No significant effect.	Destruction of benthos by dredging in St. Lawrence River (covering habitat by siltation) and mooring sites in Milwaukee and St. Ignace Harbors and on Lake Ontario.
Aesthetics	No significant effect unless vessel movement continues late into the winter months (see Alternative 3).	No significant effect.	Vessel traffic not compatible with normal tranquil winter life-style. Increased activity and noise in connecting channels, harbors, and lock areas by vessel passage. Vessel passage in winter waterways is unique and a proven attraction.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
C. Social Well-Being Effects			
Local Concerns	Adverse effect to shore property and shore structures by vessel movement in ice-covered waters in the connecting channels and harbors. Danger from oil spillage by accident of vessels moving in ice-covered waters. Disruption of recreational activities along connecting channels and in harbors (icefishing, iceskating, snowmobiling). Disruption of island transportation when vessels operate in ice-covered waters.	No damages to shore property and shore structures except that which is caused by natural conditions.	Same as 'Alternative 1' however extended to cover the St. Lawrence River. Power entities, both Canadian and U.S., request resolution of liability for damages due to disruption of power generation caused by possible ice jams in the river (caused by vessel movement). A detailed analysis and recommendation on this problem will be in subsequent interim reports.
Public Safety, Health and Welfare	Potential hazards to vessel crews, lock operating personnel, and dock and terminal workers, should shipping companies operate during the winter months. Would expect companies to provide winterized safety and survival gear, and quarters for crews to minimize safety and health concerns. Also expect lock and terminal facilities to provide adequate winter safety procedures. Disruption to recreational activities. See Effect - Local Concerns, Lesiure, Cultural and Recreational Opportunities.	Reduced safety or health hazards, except that which would be due to natural causes (i.e. thaws, winds, etc.).	Same as 'Alternative 1', however potential is reduced by more sophisticated onboard and shore navigation aids, vessel reporting systems, and reconnaissance and dissemination systems designed for winter operation. In addition, ice control devices will assist in the reduction of potential danger to persons riding carferries across the St. Marys and St. Clair Rivers by keeping ferry lanes free of ice.
Leisure, Cultural and Recreational Opportunities	Disruption of recreational activities along the connecting channels and in harbors (icefishing, iceskating, snowmobiling) should vessels move in ice-covered waters.	Maximum use of stable ice-covered waters.	Same as 'Alternative 1' however with permanent season extension, potential disruption more long-term. (A detailed investigation of recreation activities is required on the entire system and will be in subsequent interim reports).
Noise	Minimal noise as normal shipping season draws to an end. Potential periodic noise in harbors and connecting channels should vessels move in the winter months. Also vessel crews are subjected to noise of vessel moving through ice-covered waters. Vessels moving in solid ice-covered constricted areas could transmit vibrations directly to shore and shore structures (Evidenced only in St. Marys River to date).	No significant effect.	Potential noise in harbors and connecting channels during permanent extended season evident for longer period than Alternative 1. Vessel crew subjected to noise of vessel moving through ice-covered waters for longer period of time than Alternative 1. Vessels moving in solid ice-covered constricted areas could transmit vibrations directly to shore and shore structures.
Shore Structure Damage	Adverse effect along ice-covered connecting channels and harbors where structures are not already protected.	No potential damage to structures except that which occurs by natural forces.	Same as 'Alternative 1' however investigation to mitigate the problem areas of shore structure damage is being done and will be addressed in subsequent interim reports.

TABLE B-3 (cont'd)
SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
C. Social Well-Being Effects (cont'd)			
Flood Risks	Expected continuance of flooding caused by ice jams (due to vessel movement and natural conditions) and resultant damage in St. Marys and St. Clair Rivers to shore property (also possible loss of power at St. Marys powerplants)	Expected continuance of flooding caused by ice jams (caused only by natural conditions) and resultant damage in St. Marys and St. Clair Rivers to shore property (also possible loss of power at St. Marys River powerplants).	Minimize flooding potential, and resultant damage, by installation of ice control devices and water level warning systems in the St. Marys and St. Clair Rivers. (Further investigation required to identify problem areas in the St. Lawrence River, particularly impacts on power production, and the necessary mitigation measures).
Transportation (ferry)	Disruption of ice bridges which naturally form above ferry crossings in the St. Marys and St. Clair Rivers when vessels move through ice-covered waters. Disruption of island transportation to Lime Island in the St. Marys River by breaking up stable ice-cover when vessels move through ice-covered waters.	Minimal disruption of ice bridges above ferry crossings except as caused by natural breakup due to wind and thaws. Minimal disruption to stable ice-cover between mainland and Lime Island in the St. Marys River except as caused by natural conditions.	Minimal disruption and more dependable transportation of ferries by installation of ice control devices (ice booms above ferry crossings in St. Marys and St. Clair River) Minimal disruption of transportation to Lime Island in St. Marys River by use of airboat. (Further investigation required to address St. Lawrence River. This will be in subsequent interim reports).
Shore Erosion	Expected continuance of natural shore erosion along St. Marys River at selected sites. (Studies to date have certified minimal effect of winter navigation on shore erosion in St. Marys River)	Shore erosion due only to natural conditions.	Minimal shore erosion due to vessel movement in connecting channels, namely, St. Marys River. Protection is being provided to mitigate problem areas. (Further investigation required on St. Lawrence River to identify problem areas and means of mitigation).
Power	Continued possible disruption of power production in St. Marys River at Sault Ste. Marie, Michigan due to ice jams downstream caused by vessel movement or natural conditions (thaws, winds).	Same as 'Alternative 1' except subject to only natural conditions.	Minimal disruption of power production on St. Marys River by installation of ice control devices to stabilize ice cover and reduce occurrence of ice jams. (Additional studies are being made to identify benefits to power for season extension on St. Lawrence river).
Utilization of Natural Waterways	No significant effect.	Would limit utilization of waterways during winter.	Increase utilization of entire system.
D. Regional Effects			
Regional growth	No significant effect.	Regional growth would decline somewhat as a result of a restricted navigation season.	Projected net increase of approximately $1 billion dollars in labor earnings in region in year 2020 as a result of navigation season extension.
Regional employment	No. significant effect.	Slight decline in employment in region due to slower growth rate.	Projected net increase of 42,000 jobs in region by 1980 as a result of increased growth associated with navigation season extension.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

ALTERNATIVE PLANS / EFFECTS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
3. PLAN EVALUATION			
A. Contributions to Planning Objectives			
Enhance NED benefits	No	No Estimate	Yes
Enhance EQ benefits	No	Yes	Yes
Contribute to SWB	No change	Yes	Yes
Enhance Power Production	No	Yes	Yes
Maximum Use of Existing Facilities	No change	No	Yes
Better Use of an Efficient Low-Cost Mode of Transport	No change	No	Yes
Enhance Year-round Overseas Trade	No	No	Yes
Evaluates NED and EQ for all parts of System	No	No	Yes
B. Relationship to Four National Accounts			
1. NED			
COSTS Investment (1) Annual (2) Non-Federal (3)	No estimate No estimate No estimate	No estimate No estimate No estimate	* To 31 January: (1) $264,838,000 (2) $ 23,447,000 (3) Not developed * To 28 February: (1) $329,523,000 (2) $ 30,766,000 (3) Not developed * To Year-Round: (1) $329,542,000 (2) $ 33,808,000 (3) Not developed * - w/o lock twinning.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
B. Relationship to Four National Accounts			
BENEFITS			
Annual	No estimate	No estimate	* To 31 January $ 78,100,000 * To 28 February $ 176,300,000 * To Year-Round $ 200,900,000
BENEFITS/COSTS	No estimate	No estimate	* To 31 January 3.3 * To 28 February 5.7 * To Year-Round 5.9 * - w/o lock twinning
2. EQ			
Beneficial			
Improve Water Quality	Yes, by broken vessel tracks in ice	No	Yes, by broken vessel tracks and aeration units
Reduce Erosion-Sedimentation	No Change	Yes, by reduced vessel movement. Natural erosion continues.	Yes, by protecting natural erosion areas influenced by winter vessel movement.
Minimize Flood Potential	No Change	Yes, by reduced vessel movement.	Yes, by use of ice control devices.
Reduce Shore Structure Damage.	No Change	Yes, by reduced vessel movement.	Yes, by use of ice control devices.
Maintain Ice-Cover Stability	No Change	Yes, by reduced vessel movement. Natural disruption continues.	Yes, by use of ice control devices.
Reduce Air Pollution	No Change	Yes, by reduced vessel movement.	No, increased vessel activity.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

ALTERNATIVE PLANS / EFFECTS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
2. EQ (cont'd)			
Adverse			
Damage to Shore Structures	Continue existing possibility of damage in connecting channels	Reduce possible damage due to limited vessel movement	Possible increased damage due to vessel movement in constricted channels (Mitigation Measures are being investigated)
Ice Scouring	Continue existing erosion particularly in connecting channels during spring	Reduced, except that which occurs naturally	Possible increases in scouring particularly in spring.
Dredging	None	None	Possible short-term damage at ice boom anchor sites and icebreaker mooring sites. Possible long-term damage in St. Lawrence River. Mitigation measures will be addressed in subsequent interim reports.
Air Pollution	No change	Reduced due to limited vessel movement	Increased due to increased vessel activity. Mitigation measures will be addressed in subsequent interim reports.
Oil Pollution	No change	Reduced due to limited vessel movement in ice-covered waters	Continued potential for vessel accident by increased movement in ice covered waters. Mitigation measures will be addressed in subsequent interim reports.
Flooding	Continued occurrence of ice jams and flooding caused by vessel movement and natural conditions.	Reduce frequency of ice jams other than that caused naturally	Reduce potential for ice jams by use of ice control devices
Changes to Micro-climate	No change	No Change	Possible changes to thawing patterns
Loss of Environmental Variability	No change	No opportunity to extend or create possible beneficial habitat conditions.	Possible loss to animals which traditionally cross navigation channels
Ice-Cover Stability	Disruption of natural ice bridge to continue.	Reduced disruption of ice bridges except by natural causes	Increase stability of ice by use of ice control devices (i.e. ice booms) in critical areas.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS / ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
3. SWB			
Beneficial			
Minimize disruption to ferry transportation	No change	Reduce disruption due to limited vessel movement	Reduce disruption by use of ice control devices (i.e. ice booms)
Improve Public Safety Health and Welfare	No change	Reduce vessel activity would reduce number of personnel exposed to winter environment	Items such as ice control devices, improved navigation aids, and safety and survival techniques would enhance public safety, health and welfare.
Minimize Flood Risks	No change	Reduced disruption of ice-covered waters, which in turn would reduce frequency of ice jams other than that which occurs naturally	Ice control devices and water level warning systems would minimize flood risk.
Development of Natural Waterway	No change	Would reduce existing utilization	Would utilize waterway to greater extent and provide additional services
Minimize Disruption to Power Production	No change	Would reduce frequency of ice jams other than that caused by natural conditions by limited vessel movement	Would reduce frequency of ice jams by use of ice control devices.
Reduce effects on shore structures	No change	Reduce possible damage due to limited vessel movement	(Mitigation measures will be addressed in subsequent interim reports).
Adverse			
Impairment to life styles/ recreation, leisure and cultural opportunities	Disruption of winter recreational activities would occur if vessel moved in ice-covered waters	Disruption would be minimized.	Disruption of winter recreational activities would continue to occur more frequently with increased vessel activity. (Mitigation measures will be addressed in subsequent interim reports).
Disruption of power production	Vessels moving in the St. Marys River could cause ice jams which could effect power production	Disruption to power production would be realized in St. Marys River where vessel movement would not be permitted in the ice-covered river between 15 December and 1 April.	Ice control devices in the St. Marys and St. Clair Rivers would stabilize ice-cover and reduce ice jam occurrence. Similar effects are projected on St. Lawrence River.

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
3. SWB (cont'd)			
Increased level in noise	Vessel crews subjected to increased noise level when vessel is moving through ice covered waters. Vessel movement in solid ice-covered constricted channels could transmit vibrations to the shore and shore structures	Vessel crews would experience reduced noise level due to limited vessel movement	Same as 'Alternative 1' however at an increased level of vessel activity
Damage to Shore Structures	No change. Damage expected to continue in ice-covered channels as it has traditionally	Reduced damage due to limited vessel activity	Possible increased damage to shore structures beyond that which occurs naturally and under 'Alternative 1' plan. Mitigation measures are being investigated.
Increased flood risks	No damage. Ice jams which have occurred traditionally in St. Marys and St. Clair Rivers expected to continue	Reduced ice jams occurrence due to restricted vessel movement and in turn would reduce flood risks.	Ice control devices would stabilize ice cover in St. Marys and St. Clair rivers and reduce ice jam occurrence. Similar effects are projected for St. Lawrence River.
4. RD			
Beneficial			
Value of increased income	No Change	None	Net increase of approximately $1 billion in labor earnings in year 2020
Quality of increased employment	No Change	None	Increase of about 42,000 jobs in region by 1980
Desirable population distribution	No Change	No estimate	No estimate
Increased stability of regional economic growth	No Change	None	Increase. No estimate

TABLE B-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
4. RD (cont'd)			
Adverse			
Value of income lost	None	Decrease, no estimate	None
Quantity of jobs lost	None	Decrease, no estimate	None
Undesirable growth	None	Decrease, no estimate	None
C. Plan response to associated evaluation criteria			
Acceptability	Medium	Low, for industry and commerce. High, for shore property owners environmental and recreation groups	High, for industry and commerce. Medium for shore property owners and recreation groups
Completeness	High	Low	High
Effectiveness	Low	Low	High
Efficiency	Low	Low	High
Certainty	Low	Low	High
Geographic Scope	Medium	Low	High
NED B/C	0.0	0.0	* Extend to 21 January = 3.3 * Extend to 28 February = 5.7 * Extend to Year-Round = 5.9
Reversibility	High	High	High
Stability	High	Medium	High

* - w/o Lock Twinning

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS / ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
4. IMPLEMENTATION RESPONSIBILITY			
A. Corps of Engineers	Maintaining operation of lock facilities at Sault Ste. Marie, Michigan during winter months Continue monitoring ice jam reaches in St. Marys and St. Clair Rivers.	Continue monitoring ice jam reaches in St. Marys and St. Clair Rivers.	Design and construct . Assistance to Ferry transportation . Power plant protection Design construct and maintain . Harbor improvements within Federal channel units . Ice control devices (air bubblers, ice booms) in St. Marys and St. Clair Rivers. . Shore erosion and shore structure protection . Water level gauge system Operation of lock facilities at Sault Ste. Marie, Michigan Operation and maintenance of: . Bubbler-flusher unit at ferry landing docks . Airboat at Lime Island, St. Marys River
B. U.S. Coast Guard	Continue to provide icebreaking assistance services and ice jam relief services. Continue to provide search and rescue missions. Continue to provide Ice Navigation Center however at a level less than alternative 3. Continue to provide aerial reconnaissence and vessel reporting system.	Same as 'Alternative 1' (difference is only in degree of service depending upon level of vessel activity which in this case would be reduced)	Design, construction and maintain . Icebreaker fleet (Great Lakes) . Ice navigation aids . Precise Navigation Systems on Great Lakes . Mooring Improvements for Coast Guard vessels Provide and maintain . Fully staffed Ice Navigation Center . Aerial Reconnaissance . Automated Vessel Reporting System

TABLE D-3 (cont'd)

SUMMARY OF COMPARISON OF ALTERNATIVE PLANS

EFFECTS \ ALTERNATIVE PLANS	1. TRADITIONAL NAVIGATION SEASON	2. FIXED NAVIGATION SEASON	3. EXTENDED NAVIGATION SEASON
4. IMPLEMENTATION RESPONSIBILITY (cont')			
C. National Oceanic & Atmospheric Admin. (National Weather Service and Great Lakes Environmental Research Laboratory)	Continue to provide ice and weather forecast assistance to U.S. Coast Guard Ice Navigation Center	Same as 'Alternative 1' (difference is only in degree of service depending upon level of vessel activity which in this case is reduced).	Same as 'Alternative 1' however at higher level of participation
D. St. Lawrence Seaway Development Corporation	Do Nothing, except provide winter maintenance on 2 of 7 lock systems in St. Lawrence River	Same as 'Alternative 1'	Design, construct and maintain . ice control structures on St. Lawrence River . Channel clearing craft in St. Lawrence River . Dredging of selected sites in St. Lawrence River Coordination/negotiation with St. Lawrence Seaway Authority of Canada for improvements
E. Canada	Do Nothing, except provide winter maintenance on 5 of 7 lock systems in St. Lawrence River	Same as 'Alternative 1'	Provide winter operation for Welland Canal and Canadian section of the St. Lawrence River
F. Non-Federal (local)	Do Nothing	Do Nothing	Installation, operation and maintenance of private docking and terminal air bubbler units.

ALTERNATIVE 1

TRADITIONAL NAVIGATION SEASON

The Traditional Navigation Season (base condition) alternative would involve no Federal action. There would be no project improvements and there has been no associated costs or project benefits identified to date. However, there would be economic, environmental and social effects if this course of action is followed. Table D-4 summarizes the effects of alternative 1 under the four evaluation accounts.

Economic Effects

If winter operation on the Great Lakes-St. Lawrence Seaway continues as it has traditionally, the existing growth trend in the region would continue. A gradual increase in vessel use, harbor facilities and related services to accommodate normal growth in the region would occur. Tax revenues and property values would appreciate over time as the economy of the region increases.

Environmental Effects

Commercial vessels have traditionally moved in ice-covered waters throughout the Great Lakes until such time ice and weather conditions do not permit. Such movement, particularly on the St. Marys and St. Clair Rivers, has had an adverse effect on shore structures. Also, this movement has had the same effects as caused by adverse winds and has in some areas created unstable ice conditions in the immediate vicinity of the navigation channel. This unstable ice has caused ice to move and jam in constricted areas, such as in Little Rapids Cut in the St. Marys River and at the lower end of the St. Clair River. These jams have resulted in flooding in the St. Clair River and have disrupted power production and ferry transportation in the St. Marys River. However, a beneficial effect of the broken ice tracks is that sunlight and air would allow continued aeration into the winter months of the aquatic habitat.

There is always a danger of oil spills caused by vessels moving in ice-covered waters. Concerns have been expressed regarding oil

TABLE D-[illegible]

SYSTEM OF ACCOUNTS

NS PLAN - TRADITIONAL NAVIGATION SEASON

LOCATION / EFFECTS	Timing *	PROJECT AREA: Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
1. National Economic Development								
Beneficial								
Transportation savings (annual)				—			—	—
Stockpiling savings Capital costs (annual)				—			—	—
Real estate (annual)				—			—	—
Handling (annual)				—			—	—
Vessel utilization savings (annual)				—			—	—
Total NED Benefits	I			No estimate			No estimate	No estimate
Adverse								
Project Costs (annual)				—			—	—
Loss of transportation savings, stockpiling savings and vessel utilization savings (annual)				—			—	—
Total NED Costs	I			No estimate			No estimate	No estimate
Net NED Benefits	I			No estimate			No estimate	No estimate
2. Environmental Effects								
Beneficial								
Continued aeration of aquatic habitat	I, II, III	—	Broken tracks in the ice cover due to vessel movement allows continued aeration	Same as Harbors.	—	Same as Harbors.	—	—
Adverse								
Damage to shore structures	I, II	—	Possible damage to shore structures by vessels moving in ice-covered waters. (Mitigation measures are under investigation and will be addressed in subsequent interim reports.	Same as Harbors.	Continued wear on lock walls and equipment.	Same as Harbors.	—	—

* - See page D-49

TABLE D-4 (cont'd)

NS PLAN

LOCATION / EFFECTS	Timing *	Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
		PROJECT AREA						
2. Environmental Effects (cont'd)								
Ice Scouring	I, II	—	Expected continuance of natural erosion and sedimentation with possible additional effect depending upon length of navigation season.	Same as Harbors.	—	Same as Connecting Channels.	—	—
Air Pollution	I, II, III	—	Vessel smog would be evident during the winter months.	Same as Harbors.	—	Same as Harbors.	—	—
Flooding	I, II	—	—	Expected continuance of flooding in St. Marys and St. Clair Rivers caused both by vessel movement and natural conditions.	—	Investigation required to identify problem areas)	—	—
Ice-cover Stability	I, II, III	—	Vessel movement in ice-covered waters would create unstable ice in vicinity of vessel tract and could cause ice to break away from shoreline.	Same as Harbors. Development of natural ice bridges in St. Marys and St. Clair Rivers would be retarded.	—	—	—	—
3. Social Well Being								
Beneficial								
Adverse								
Potential damage to shore structures	I, II	—	Continued potential of damage should vessels move into ice-covered waters during the winter months.	Same as Harbors.	—	—	—	—
Potential disruption of recreational and leisure activities	I, II III	Potential disruption of ice-cover near vessel tracts at entrances to the connecting channels.	Same as Lakes except applies to inner harbor areas.	Same as Lakes except applies to connecting channels areas.	—	—	—	—
Disruption of ferry transportation	I, II	—	—	Continued potential of disruption of ferry operation by breaking natural ice bridge above ferry crossing in St. Marys and St. Clair Rivers by vessel movement and natural conditions	—	—	—	—

* - See page D-49

TABLE D-4 (cont'd)

NS PLAN

EFFECTS \ LOCATION	Timing *	PROJECT AREA: Lakes	PROJECT AREA: Harbors	PROJECT AREA: Connecting Channels (incl. Welland Canal)	PROJECT AREA: Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	PROJECT AREA: St. Lawrence River	GREAT LAKES REGION	REST OF NATION
3. Social Well-Being (cont'd)								
Potential of hazard to public safety, health and welfare	I, II	Vessels moving in ice-covered waters during the winter months subject crews to possible exposure (Expect companies to provide adequate protection).	—	Same as Lakes	—	—	—	—
Potential Noise	I, II	Vessel crews subjected to noise of vessels moving through ice-covered waters.	—	Same as Lakes	—	—	—	—
Continued flood risks	I, II	—	—	Continued flood potential due to ice jams caused by vessel movement and natural conditions in St. Marys Marys and St. Clair Rivers.	—	—	—	—
4. Regional Development								
Beneficial								
Value of increased income	I			—			No change.	No change.
Quality of increased employment	I			—			No change.	No change.
Desirable population distribution	I			—			No change.	No change.
Increased stability of regional economic growth	I			—			No change.	No change.
Adverse								
Value of income lost	I			—			None.	None.
Quantity of jobs lost	I			—			None.	None.
Undesirable growth	I			—			None.	None.

* - See page D-49

LEGEND

Timing

I - Impacts that are expected prior to or during plan implementation.

II - Impacts that are expected in a short time frame. Over the life of the plan, these will generally be impacts that will occur in 15 years or less.

III - Impacts that are expected in a long time frame. Over the life of the plan, these will generally be impacts that will occur later than 15 years.

spills and their effect upon waterfowl and aquatic habitat.

Natural shore erosion and sedimentation in constricted areas of the connecting channels and lakes is expected to continue. Vessel smog would be evident during the winter months.

Social Effects

As stated in the environmental effects section, shore structures and shore property are subjected to possible damage during the winter months by vessel movement in constricted areas. However, it is important to note that natural conditions also may cause such damage.

Unstable ice conditions in the vicinity of the navigation channels has disrupted outdoor recreation, such as icefishing and snowmobiling, in the St. Marys River and Lake St. Clair. This would continue.

Ice jams caused by the movement of the unstable ice have disrupted power production in the St. Marys River at Sault Ste. Marie and have also disrupted ferry transportation. Disruption of power production has been experienced on the St. Lawrence and Niagara Rivers; however, these were caused by natural conditions (i.e. wind) and not navigation.

The winter environment presents potential hazards, by exposure, to vessel crews, lock operating personnel and terminal workers. It is expected, however, that proper equipment, such as safety and survival gear, clothing and winterized quarters would be furnished these personnel.

Vessel crews are also subjected to the noise of movement through ice-covered waters when the ice scrapes along the vessel sides. Concerns have been expressed on the St. Marys River that vibrations from vessels moving in nearby contricted areas were transmitted to the shore and shore structures.

As stated in the previous section, flooding of adjacent land to the connecting channel, particularly in the St. Clair River, has been experienced and would continue to occur.

ALTERNATIVE 2

FIXED NAVIGATION SEASON

This alternative, as the Traditional Navigation Season alternative, would involve no Federal action. There would be no project improvements and there has been no associated costs or project benefits identified to date. However, there would be economic, environmental, and social effects if this course of the action is followed. Table D-5 summarizes the effects of alternative 2 under the four evaluation accounts. Since this plan affects only traditional navigation on the upper four Great Lakes portion of the system, there would be no effects on the St. Lawrence River portion of the system.

Economic Effects

This plan would limit vessel traffic between Lake Superior and the lower lakes to a period between 1 April and 15 December. The resultant limited traffic movement would reduce commodity movement which has occurred traditionally and as a result would tend to reduce the existing growth trend of the region.

Business and industrial activity would decline somewhat. Some harbor communities would experience an increased migration of seasonal and unemployed workers out of the area, thereby disrupting community growth. A reduction in harbor facilities and related services would be experienced.

Environmental Effects

This particular plan, is considered the most environmentally acceptable. Limited vessel movement between Lake Superior and the lower lakes, from 1 April to 15 December, would reduce possible damages, other than that which is caused naturally, to the shoreline and shore structures and reduce the effect on the overall environment.

TABLE D-5

SYSTEM OF ACCOUNTS

EQ PLAN - FIXED NAVIGATION SEASON

EFFECTS / LOCATION	Timing *	PROJECT AREA: Lakes	PROJECT AREA: Harbors	PROJECT AREA: Connecting Channels (incl. Welland Canal)	PROJECT AREA: Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	PROJECT AREA: St. Lawrence River	GREAT LAKES REGION	REST OF NATION
1. National Economic Development								
Beneficial								
Transportation savings (annual)				—			—	—
Stockpiling savings Capital cost (annual)				—			—	—
Real estate (annual)				—			—	—
Handling (annual)				—			—	—
Vessel utilization savings (annual)				—			—	—
Total NED Benefits	I			No estimate			No estimate	No estimate
Adverse								
Projects costs (annual)				—			—	—
Loss of transportation savings, stockpiling savings, and vessel utilization savings (annual)	I, II			—			No estimate	—
Total NED Costs	I, II			No estimate			No estimate	No estimate
Net NED Benefits	I, II			No estimate			No estimate	No estimate
2. Environmental Effects								
Beneficial								
Reduce shore structure damage	I	—	—	Reduce potential damage to docks and shore structures by not allowing vessel movement after 15 December.	—	—	—	—
Maintain stability of ice-cover	I	—	Ice-cover would not be disrupted by vessel movement unless there is early freeze before 15 December.	Same as Harbors. Migratory patterns of animals crossing ice in St. Marys River not disrupted by vessel movement.	—	—	—	—

* - See page D-49

TABLE D-5 (cont'd)

EQ PLAN

LOCATION / EFFECTS	Timing *	PROJECT AREA: Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
2. Environmental Effects (cont'd)								
Fauna		No change to migratory patterns of fish and waterfowl.	Same as Lakes.	Same as Lakes.	—	Same as Lakes.	—	—
Reduce potential flooding caused by vessel movement	I	—	—	Reduce potential of ice jams caused by vessels breaking stable ice-cover.	—	—	—	—
Reduce air pollution	I	—	Reduce vessel fog during early winter.	Same as Harbors.	—	—	—	—
Adverse								
Loss of environmental variability	I, II	—	No opportunity to extend or create possible beneficial habitat conditions for plant and animal life.	Same as Harbors.	—	—	—	—
3. Social Well-Being								
Beneficial								
Minimize effect on recreational activities	I	Minimize disruption to iceskating, icefishing and snowmobiling activities near connecting channel entrances.	Same as Lakes however applying to inner harbor areas.	Same as Lakes however applying to channel areas.	—	Same as Lakes however applying to channel areas.	—	—
Reduced effect on shore structures	I	—	Reduce possible damage to structures by not operating in ice-covered waters (any effect caused only by natural conditions).	Same as Harbors.	—	—	—	—
Minimizes health hazards	I	Vessel crews not subjected to working in winter environment.	Same as Lakes extended to dock and terminal workers.	Same as Lakes extended to recreational activities.	Same as Lakes extended to lock operating personnel.	—	—	—
Minimizes disruption to ferry transportation	I	—	—	Minimizes disruption of ice bridges above ferry crossings on St. Marys and St. Clair Rivers except for that which occurs naturally. Minimal disruption to ice-cover between Lime Island and the mainland in St. Marys River except for that which occurs naturally.				

* – See page D-49

TABLE D-5 (cont'd)

EQ PLAN

LOCATION / EFFECTS	Timing*	PROJECT AREA: Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
3. Social Well-Being (cont'd)								
Adverse								
Continuance of Flooding Potential	I	—	—	Expected continuance of possible flooding due to ice jams in the St. Marys and St. Clair Rivers caused by natural conditions. (Potential effect on power production in the St. Marys River.	—	—	—	—
Lack of utilization of Natural Waterways	I, II, III	Would limit utilization of natural waterway for movement of commerce.	Same as Lakes.	Same as Lakes.	Same as Lakes.	Same as Lakes.	Same as Lakes.	Reduced utilization of a natural waterway which services approximately 1/3 of the nation.
4. Regional Development								
Beneficial								
Value of increased income	II			—			None.	No estimate.
Quality of increased employment	II			—			None.	No estimate.
Desirable population distribution	II			—			No estimate.	No estimate.
Increased stability of regional economic growth	II			—			None.	No estimate.
Adverse								
Value of income lost	II			—			Decrease, no estimate.	No estimate.
Quantity of jobs lost	II			—			Decrease, no estimate.	No estimate.
Undesirable growth	II			—			Decrease, no estimate.	No estimate.

* – See page D-49

The limited movement of vessels would cut down on air pollution from vessel smog and reduce the damage of oil spills by vessel accidents. However, ice jams may continue to occur from natural conditions (i.e. thawing, winds) in the St. Marys and St. Clair (including lower Lake Huron) Rivers depending upon meteorological conditions. Such jams may disrupt ferry transportation in the St. Marys River at Little Rapids Cut and cause flooding in the St. Clair River. However recent records have shown that ice jams are minimal on the St. Clair River during the months of December and January and are decreasing in magnitude.

Social Effects

The stable ice-cover in the St. Marys River and Lake St. Clair, between the St. Clair and Detroit Rivers, and St. Lawrence River would enable maximum use of ice-covered waters particularly for outdoor recreation (icefishing, snowmobiling, iceboating, ice skating). This condition would also reduce safety and health hazards in these areas.

The stable ice-cover would also reduce possible damages to shore structures and the shoreline.

ALTERNATIVE 3

EXTENDED NAVIGATION SEASON

This alternative would involve Federal action. This plan would provide for an extension of the navigation season beyond the traditional closing date of 15 December on the Great Lakes-St. Lawrence Seaway System to as much as year-round.

Specifically, there were three dates of season extension evaluated: (1) 31 January, (2) 28 February, and (3) year-round.

There would be economic, environmental and social effects if this course of action is followed. Table D-6 summarizes the effects of alternative 3 under the four evaluation accounts.

Economic Effects

Project cost, benefits and resultant benfit/cost ratios are displayed in the following table.

	Extended Season		
	31 January	28 February	Year-round
Investment Costs	$264,837,600	$329,523,400	$329,542,000
*Annual Costs	$ 23,446,700	$ 30,765,800	$ 33,808,000
**Annual Benefits	$ 78,100,000	$176,300,000	$200,900,000
Benefit/Costs	3.3	5.7	5.9

* - Total U.S. Costs w/o Lock Twinning

** - Sources of benefits: Transportation savings, stockpilings (capital, real estate, handling) and vessel utilization savings.

This alternative would provide accelerated growth in the region and as a result would cause additional increases in overall regional property values, increases in revenues to states, counties, and communities; increases in employment; and increased use of business, harbor and industrial facilites, particularly in the commercial shipping industry

TABLE D-6

SYSTEM OF ACCOUNTS

NED PLAN – EXTENDED NAVIGATION SEASON

LOCATION / EFFECTS	Timing*	PROJECT AREA: Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
1. National Economic Development								
Beneficial								
Transportation savings (annual)	I							
Stockpiling savings Capital costs (annual) Real estate (annual) Handling (annual)	II				31 January	28 February	Year-round	
				Average Annual Benefits	\$ 78,100,000	\$176,300,000	\$200,900,000	
				Average Annual Costs	\$ 23,447,000	\$ 30,766,000	\$ 33,808,000	
Vessel utilization savings (annual)	II							
				Net Annual Benefits	\$ 54,653,000	\$145,534,000	\$167,092,000	
Total NED Benefits								
Adverse								
Project costs (annual)	I							
Loss of transportation savings, stockpiling savings and vessel utilization savings (annual)								
Total NED Costs	I							
Net NED Benefits	I							
2. Environmental Effects								
Beneficial								
Improve water quality	II	—	Aeration of water during air bubbler operation and through vessel tracks broken in stable ice-cover.	Same as Harbors.	—	—	—	—
Reduce erosion-sedimentation	II	—	—	Protection of identified areas subject to natural erosion. (More comprehensive investigation required).	—	(Further investigation required to assess problem areas and mitigation measures)	—	—

* – See page D-49

TABLE D-6 (cont'd)

NED PLAN

EFFECTS \ LOCATION	Timing *	Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
		PROJECT AREA						
2. Environmental Effects (cont.)								
Minimize flood potential	I	—	—	Ice control devices will stabilize the ice-cover above natural ice jam areas	—	—	—	—
Provide protection for shore structures	I, II	—	—	(Problem areas are to be identified and mitigation measures developed.)	—	—	—	—
Adverse								
Damage to shore structures (incl. locks)	I	—	Possible increase of damage to unprotected docks facilities beyond that caused by natural conditions (Mitigation measures will be addressed in subsequent interim reports).	Same as Harbors.	Greater wear on lock walls and equipment. Lock gates more susceptible to damage and service problems.	Same as Harbors. (Problem areas and mitigation measures will be addressed in subsequent interim reports).	—	—
Ice Scouring	II	—	Possible increased erosion to shoreline and sedimentation beyond which occurs naturally, particularly during spring break-up of ice.	Same as Harbors (to include wetlands).	—	Same as Connecting Channels (Investigation required to determine problem areas and mitigation measures).	—	—
Dredging & Drilling	I, II	—	Possible short-term damage to harbor bottom at mooring sites for icebreakers in Milwaukee and St. Ignace Harbors (incl. benthos).	Possible short-term damage to channel bottom at ice boom anchor sites in the St. Marys and St. Clair Rivers (incl. benthos).	—	Possible long-term damage to river bottom at channel dredging sites. Possible short-term damage to channel bottom at ice boom anchor sites (incl. benthos).	—	—
Increased air pollution	I, II, III	—	Increased vessel activity would increase vessel smog not normally encountered during the winter months.	Same as Harbors	—	Same as Harbors.	—	—
Increase potential for oil pollution	I, II, III	Increased potential for vessel accidents by vessels moving in ice-covered waters.	Same as Lakes.	Same as Lakes.	—	Same as Lakes.	—	—
Flooding	I	—	—	—	—	Increase potential for flooding by disrupting stable ice-cover and causing ice-jams. (Power generation directly effected).	—	—

* - See page D-49

TABLE D-6 (cont'd)

NED PLAN

EFFECTS \ LOCATION	Timing *	Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
		PROJECT AREA						
2. Environmental Effects (cont'd)								
Changes to Micro-Climate	I, II, III	—	Possible changes to thawing patterns (assessment to be in subsequent interim reports)	Same as Harbors.	—	Same as Harbors.	—	—
3. Social Well-Being								
Beneficial								
Minimize disruption to ferry transportation	I, II, III	—	—	Installation of ice control devices above ferry crossings in St. Marys River and St. Clair River would improve existing conditions. Airboat at Lime Island in St. Marys River would maintain transportation through periods of thaw.	—	(Problem areas to be identified and addressed in subsequent interim reports)	—	—
Improved Public Safety, Health and Welfare	II, III	Improved on-board and shore navigation aids, ice data collection and dissemination systems, and safety and survival designed for the winter environment will enhance the safety of the vessel crews.	—	Same as Lakes. Installation of ice control devices above ferry crossings in St. Clair and St. Marys Rivers would minimize ice interruption with ferry movement and minimize possible ferry damage when carrying passengers.	—	Same as Lakes.	—	—
Minimize flood risks	II, III	—	—	Installation of ice control devices and water level warning systems in the St. Marys and St. Clair Rivers would minimize potential floods by stabilizing the ice-cover and preventing it from jamming in constricted areas.	—	(Investigation required to identify problem areas and mitigation measures).	Stabilization of power production from plants on St. Marys River.	—
Development of Natural Waterway	III	Utilizes waterways to more extent and provides additional services.	Same as Lakes.	Same as Lakes.	Same as Lakes	Same as Lakes (In addition to power production)	—	—

* - See page D-49

TABLE D-6 (cont'd)
NED PLAN

LOCATION / EFFECTS	Timing *	PROJECT AREA: Lakes	Harbors	Connecting Channels (incl. Welland Canal)	Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	St. Lawrence River	GREAT LAKES REGION	REST OF NATION
3. Social Well-Being (cont'd)								
Minimize disruption to power generation	I, II, III	---	---	See Effect - Minimize flood risks.	---	(Detailed investigation required to determine impacts).		
Development of Natural Resources	II, III	---	---	---	---	---	Extended season would enable further development of natural resources of the region, namely, iron ore, coal, stone and grain.	---
Aesthetics	I, II, III	---	Vessel operation in winter is unique and a proven attraction.	Same as Harbors.	Same as Harbors.	Same as Harbors.	---	---
Adverse								
Impairment of life styles/recreation, leisure and cultural opportunities	I, II	Possible disruption of recreational activities (iceskating, icefishing, snowmobiling) by weakening areas of stable ice at entrances to connecting channels.	Same as Lakes however applies to inner harbor areas.	Same as Lakes however applies to channel areas.	---	Same as Lakes. (Problem areas need to be identified).	---	---
Disruption of power production.	I, II	---	---	See Effect - Minimize flood risks.	---	Increased potential of disruption of the ice-cover established for power production by vessel movement in the river channels. (The amount of effect and resultant liability for damages will be addressed in subsequent interim reports).	Increased potential of disruption of power for the region.	---
Vessel crews subjected to noise of vessel breaking ice.	I, II	Vessels operating in ice-covered waters make significant noise when breaking through the ice-cover.	---	Same as Lakes.	---	Same as Lakes.	---	---
Damage to shore structures	I, II	---	Possible increase of damage to unprotected docks beyond that which is caused by natural conditions.	Same as Harbors.	---	(Further investigation required to assess problem areas and mitigation measures)	---	---

* - See page D-49

TABLE D-6 (cont'd)

NED PLAN

EFFECTS \ LOCATION	Timing *	PROJECT AREA: Lakes	PROJECT AREA: Harbors	PROJECT AREA: Connecting Channels (incl. Welland Canal)	PROJECT AREA: Locks (incl. St. Marys River, Welland Canal, St. Lawrence River)	PROJECT AREA: St. Lawrence River	GREAT LAKES REGION	REST OF NATION
4. Regional Development								
Beneficial								
Value of increased income	II			—			Net increase of approximately $1 billion in labor earnings in year 2020.	No estimate.
Quality of increased employment	II			—			Increase of about 42,000 jobs in region by 1980.	No estimate.
Desirable population distribution	II			—			No estimate.	No estimate.
Increased stability of regional economic growth	II			—			Increase, no estimate.	No estimate.
Adverse								
Value of income lost	II			—			None.	No estimate.
Quantity of jobs lost	II			—			None.	No estimate.
Undesirable growth	II			—			None.	No estimate.

* – See page D-49.

and in those industries that are users of the region's bulk and general cargo commodities.

It is projected that a net increase of approximately $1 billion in labor earnings in the region in year 2020 would result from navigation season extension. Projected employment in the region would increase by 42,000 jobs by 1980.

Environmental Effects

This alternative would provide for increased vessel activity during the winter months as compared to the other two alternatives. As a result, the potential for damages to the shore and shore structures increases. However, ice control devices would be provided to reduce the movement of ice as a result of the increased vessel activity. For instance, a floating ice boom would be provided at the head of Little Rapids Cut in the St. Marys River just downstream from Sault Ste. Marie (Soo), Michigan. This boom would serve several purposes: (1) it would stabilize the ice in the Soo Harbor area and reduce the amount of ice floating into the Cut area, (2) this, in turn, would reduce potential damages to the shore and shore structures along the Cut, (3) the occurrence of ice jams at the lower end of the Cut would be minimized and the backwater effects on the powerplants in Soo Harbor, which disrupts power production, would be minimized, and (4) ferry transportation across the Cut to and from Sugar Island would be maintained with minimal disruption.

Another prime example of ice control would be at the head of the St. Clair River. A similar type ice control device as in the St. Marys River would be installed across the mouth of the river to retard ice floe from Lake Huron into the river. This ice traditionally has caused ice jams in the lower St. Clair and resultant flooding of adjacent land area. This ice control device would not only reduce the occurrence of ice jams but would also minimize the disruption of the shore and shore structures along the river due to the ice floes.

Installation of the ice booms will require a minimal amount of dredging and drilling for anchors and the disruption to the channel bottom would be short term.

Dredging is also considered necessary in the St. Lawrence River for ice boom anchors; however, for season extension of one month or more, it may also be necessary to deepen sections of the navigation channel near St. Regis and Ogden Islands to reduce the velocity of water in this area and, in turn, would enable the establishment of a stable ice-cover.

Dredging for ice boom anchors and mooring sites in Milwaukee and St. Ignace Harbors and in the St. Lawrence River would have a short term effect upon the aquatic habitat in these areas (i.e. fish migration and spawning and nursing areas, benthos). Potential long term damage to the channel bottom (aquatic habitat, benthos) is anticipated as a result of the channel deeping in the St. Lawrence River, however, recovery is expected. A detailed assessment has not been made and will be presented in subsequent interim reports.

Increased vessel activity under this alternative would also tend to increase the level of vessel smog throughout the areas where vessels are operating. Also there is an increased potential for oil spills; however, ongoing research and new vessel construction would reduce the potential damages.

As stated in the previous paragraphs, flooding at flood prone areas in the Great Lakes area, namely in the Soo Harbor area of the St. Marys River and at the lower end of the St. Clair River would be reduced through the installation of ice control devices in these rivers. This would even provide an environmental benefit because it would enhance, through mitigation, the protection of the environment in these areas.

Another environmental effect is in regard to aesthetics. Traditionally winter vessel operation has been minimal and the winter life-

style tranquil. Extended season navigation would disrupt this tranquility by increased activity and noice; however, it should be mentioned that vessel passage in the Great Lakes-St. Lawrence Seaway System has always held a certain fascination because it is unique, regardless of the season of the year.

Social Effects

Concerns have been expressed at public meetings regarding potential damages to the shore and shore structures by vessel operations in constricted areas of the connecting channels, namely the St. Clair and St. Marys River. To assist in the mitigation of these potential damages, ice control devices (i.e. ice booms), would be provided upstream of these constricted areas to minimize the ice floes into these areas. Ice jams would be reduced and flooding would be minimized. Damages to the shore and shore structures are recognized and estimates are currently being developed of these damages and they will, in turn, be charged as a cost against the project.

Potential hazard to public safety, health and welfare have been expressed as a concern. However, specially designed on-board and shore navigation aids, real-time ice and weather data collection and dissemination systems, safety and survival gear, and icebreaking assistance would be provided to reduce this potential hazard. Ice control devices, as described in previous sections, would be provided upstream of ferry crossings to keep the ferry lanes free of ice. These would minimize any potential disruption of the ferries and reduce possible dangers to persons riding the ferries.

Outdoor recreation such as icefishing, ice skating, and snowmobiling would be disrupted and winter navigation would probably cause the areas of activity, which have traditionally occurred near the navigation channels, to move because of unstable ice conditions near the channel. Consequently, there would be a loss of recreation areas if ice in heavily used areas is broken up or otherwise rendered unstable.

Noise is another effect of winter navigation which has been expressed by vessel crews. Ice scraping along the sides of ships moving through ice makes noise which is bothersome to the vessel crews. Ships' crews have traditionally experienced this phenomena and with an extended season program would experience it for longer periods of time into the winter months.

A particular social effect and one of the most significant on the St. Lawrence River is the potential disruption of power generation by plants located along the river which use the water for power generation. In the St. Lawrence River, additional ice booms are projected to enable winter navigation. These booms are projected to improve the levels and flows regime. They will, by stabilizing the ice cover, reduce ice jams in constricted areas and, in turn, enable a uniform water flow in the river for power production.

The ice booms are currently not designed to permit navigation through them. A very significant concern as expressed by the power entities (both U.S. and Canada) along the river is the question of liability for damages should navigation be permitted in the river and disrupt the stable ice cover. This will be addressed fully in subsequent interim reports.

A systems study of the St. Lawrence River is displayed in Appendix IV on the engineering feasibility of winter navigation in the St. Lawrence River and improvements needed to enable winter navigation.

It is important to note that potential adverse effects are recognized in conjunction with extended season navigation. Possible mitigation of these effects will be further investigated and reported upon in subsequent interim reports on the Great Lakes-St. Lawrence Seaway Navigation Season Extension Study.

SELECTING A PLAN

In selecting a plan, each of the three alternatives, specifically,

(1) Traditional Navigation Season (base condition)

(2) Fixed Navigation Season

(3) Extended Navigation Season

were evaluated as to relative impacts and contributions to the specific planning objectives of the study and their contributions to the broad national planning objectives of National Economic Development (NED) and Environmental Quality (EQ), and the associated accounts of Social Well-Being (SWB) and Regional Development (RD).

The most direct indicator reflecting the enhancement of national economic development is the economic return of each plan. Of the three plans considered, only Alternative 3 provides an economic return, as compared to base conditions, and satisfies the NED objective. Alternative 2 would reduce the existing economic growth trends of the region by limiting the movement of existing commercial traffic. Alternative 1 only addresses itself to existing growth trends of the region.

Regarding the enhancement of environmental quality, Alternative 2 is considered to provide the most towards the EQ objective by limiting the movement of commercial vessel traffic in ice-covered waters which may occur under existing conditions if shipping companies chose to move commodities during the winter months. The ice-cover in restricted areas, such as in channels

and harbors, would not be disturbed, except due to natural conditions (winds, thaws); and consequently the frequency of occurrence of potential effects due to vessel movement, such as shore structure damage, oil and air pollution, and ice jams would be reduced.

Under Alternative 3, certain undesirable effects of winter navigation are recognized such as shore structure damage, disruption of ferry transportation, and flooding as a result of ice jams. However, mitigation measures such as the installation of ice control devices (i.e, floating log booms), riprapping the shoreline to reduce erosion, installation of pile clusters near shore structures for protection are being addressed to minimize any significant adverse effects on the environment, and thereby protecting the environment. The installation of ice control devices above natural ice jam areas in the St. Marys and St. Clair Rivers would alleviate potential ferry transportation problems and ice jams. These structures would actually tend to improve existing conditions by stabilizing the ice-cover during thaw and wind conditions, reducing ice movement and damage to shore structures, and thereby enhancing the environmental quality. In addition, these structures would contribute to social well-being by maintaining ferry transportation and not allowing the ice to jam to a point where it would impede ferry movement across the St. Marys and St. Clair Rivers as it does under existing conditions because there is nothing to prevent the ice from moving. Also, the lessening of potential ice jams in the St. Marys River and the control of ice floe into the St. Clair River would have a direct beneficial effect on power interests located on these rivers which the other two alternatives do not provide. Similar effects are projected for the St. Lawrence River.

Of the three plans, only Alternative 3 contributes to regional development above existing conditions. Increases in jobs and resultant labor earnings, increased revenues, and a stimulation of the business and industrial activities of the region, particularly associated with the commercial shipping and industry, is a direct contribution to regional development.

Regarding the maximum use of existing facilities, Alternative 1 and 2 would not contribute to this objective. Facilities such as at the locks in the St. Marys and St. Lawrence Rivers and the Welland Canal traditionally have remained idle during the winter months. The same applies to harbor and terminal facilities. Alternative 3, however, uses existing facilities to a much greater extent than either of Alternatives 1 and 2.

Commercial vessels have traditionally been laid-up during the winter months. Alternatives 1 and 2 would continue this policy. Alternative 3 would better use this efficient low-cost mode of transportation for transport of both bulk commodities and general cargo throughout the year.

Navigation has traditionally been closed on the St. Lawrence River during the winter months due to ice and weather conditions. Under Alternatives 1 and 2 this policy would continue not allowing overseas trade to come into the Great Lakes between mid-December and early April. Considerable economic returns have been projected if the Great Lakes are open to overseas trade longer than the normal 8 1/2 month Great Lakes shipping season. Alternative 3 would open up this trade avenue (St. Lawrence River) to overseas traffic for a longer period of time and, in turn, enhance year-round overseas trade.

For these reasons, Alternative 3 - Extended Navigation Season, was determined to best fulfill the broad national and specific planning objectives of the study. Therefore, it is designated as the Selected Plan.

ATTACHMENT 2 TO APPENDIX B

ENGINEERING STUDIES
AND
PRIOR AND ON-GOING STUDIES

ENGINEERING STUDIES

Each of the problems identified and shown in the "Engineering Problems/Alternative Solutions Table" has been examined separately, using results from the Demonstration Program; past studies; surveys, charts, maps, and aerial photos; interviews with local residents, local government officials, and operation personnel at ferry, lock or harbor facilities; and extensive coordination with private and governmental representatives who have engineering and scientific expertise related to the problem and/or site of the problem. Prior and on-going studies that were considered or referenced in the analysis of problems and alternative solutions were addressed in the Prior and On-Going Studies Section of this attachment.

TABLE 1

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE SUPERIOR			
I. Open Lake	A. Vessel Movement through ice rafting and windrows	1. Icebreaker assistance	
	B. Ice & weather information operations for shippers	1. Aerial & ground ice reconnaissance 2. Side-Looking Airborne Radar (SLAR) 3. Ice Navigation Center 4. Aircraft overflights to locate leads (open water passageways in ice)	
	C. Aids to navigation	1. LORAN-C 2. Radar transponder beacons 3. Fixed navigation lights	
	D. Vessel-crew safety/survival and Search and Rescue	1. Float-off crew capsules (group survival protection) 2. All weather individual survival suits 3. Man-overboard alarms 4. Emergency Position Indicating Radio Beacons (EPIRBS) 5. Vessel Monitoring/reporting system	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE SUPERIOR (Cont.)			
I. Open Lake (Cont.)	E. Prevent Spills of oil & other hazardous substances	1. Monitor hazardous material vessel movement 2. Routine vessel inspection 3. Continue review and implementation of existing plans 4. Implement EPOA	
	F. Water Quality	1. Analysis underway 2. Implement EPOA	1. Regulate to prevent vessel waste discharge 2. Holding tanks 3. Vessel discharge facilities in harbors
II. Harbors	A. Vessel movement thru shifting ice at entrances	1. Ice booms 2. Ice breaker assistance	1. Ice stabilization islands, piles & cells 2. Air bubbler systems 3. Thermal ice suppression 4. Ice removal systems
	B. Ice conditions within harbors	1. Air bubblers 2. Maintenance of vessel tracks 3. Icebreaking tugs - privately furnished	1. Same as Lake Superior, para. II., A.

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE SUPERIOR (Cont.)			
II. Harbors (Cont.)	C. Lack of all-weather aids to navigation	1. LORAN-C 2. Radar Transponder Beacons 3. Fixed visual aids to navigation	
	D. Mooring facilities for icebreakers	1. Additional icebreakers will require additional mooring facilities	1. Consolidate mooring facility sites
III. Whitefish Bay	A. Vessel movement thru shifting ice conditions	1. Maintain vessel tracks 2. Icebreaking assistance 3. Vessel convoys 4. Aircraft overflights to locate leads (open water passageways in ice) 5. Air bubbler system	
	B. Ice and Weather Information Operations for Shippers	1. Same as Lake Superior para. I., B	
	C. Lack of all-weather aids to navigation	1. LORAN-C 2. Radar Transponder Beacons 3. Fixed navigation aids	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER			
I. St. Marys Falls Canal (Soo Locks)	A. Removing Ice collar on lock walls	1. Co-polymer coating of lock walls 2. Steam outlets at top of lock wall 3. Steamlines recessed in lock wall	1. Tractor-backhoe unit 2. Tractor mounted 16 foot chainsaw bar 3. Tug mounted with scraper blade
	B. Ice prevention in lock chambers, gates, and boom machinery recesses	1. Air bubblers along lock chamber floor 2. Heating cables in gate machinery recesses 3. Air bubblers in gate recesses, stoplog sites & dewatering gate	1. Maintain water current in lock chamber by valves
	C. Removing ice out of lock	1. Butterfly valves in upstream gates 2. Tug to herd ice from lock chamber at low pool level	1. Provide current in lock chamber by opening filling valves at low pool level with down-stream gates open
	D. Ice in gate recesses	1. Air bubbler/flushers in gate recesses	1. Co-polymer coating in gate recesses 2. Velocity inducing system in upstream gate area

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
I. St. Marys Falls Canal (Soo Locks) (Cont.)	E. Wear and tear on lock mechanical & structural equipment	1. Replace and increase air compressor capacity 2. Replace steamplant facility 3. Increase frequency of lock gate surface painting 4. Prepare emergency plans for equipment repair	
	F. Wear and tear on floating plant	1. Modify tugs "OWEN M. FREDERICK" and "WHITEFISH BAY" 2. Icebreaking tug 3. Modify derrickboat "HARVEY" 4. Modify gatelifter "PAUL BUNYAN" 5. Provide plant repair period	
	G. Revision of maintenance program	1. Reschedule lock maintenance	
	H. Safety boom operation	1. Permanent housing around boom rolling segments 2. Protection panels at fenders boom socket receiver 3. Modify floor drains in fender boom recesses and install heat cables	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
I. St. Marys Falls Canal (Soo Locks) (Cont.)	I. Abrasion on walls and culverts	1. Monitoring and mandatory periodic culvert and wall inspections	
	J. Bottom scouring in west approach channel	1. Increase shoal removal operations	1. Annual temporary reassignment of Detroit District derrickboat to locks 2. Dredging loose rock
	K. Removing ice from upstream lock entrance	1. Air curtain bubbler 2. Air bubbler system along pier 3. Ice boom and fixed logs 4. Diverting ice thru adjacent lock 5. Heating wall structures	1. Flow developers 2. Tug with scraper blade 3. Ice harvesting 4. Warm water diversion
	L. Removing ice from downstream lock entrance	1. Tug with scraper 2. Air bubbler system along pier 3. Gate valves in downstream gates at low pool level	1. Air curtain bubbler 2. Flow developers 3. Ice harvesting 4. Warm water diversion 5. Flow diversion - U.S. Hydro Plant 6. Tugs with sweep boom

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
I. St. Marys Falls Canal (Soo Locks) (Cont.)	M. Ice formation on lock gates	1. Steam heating gates	
	N. Lock wall fender damage	1. Annual replacement of timber fenders on piers and gates	1. Replace timber with rubber fenders
	O. Passage of 105' x 1000' vessels	1. Increase air volume supply at entrance 2. Increased maintenance on gate mechanical equipment	
II. Island Access Transportation	A. Sugar Island	1. Ice navigation boom 2. Ice stabilization islands 3. Preventive ice-breaking 4. Relocation of Soo sewage treatment plant outfall	1. Ice stabilization nylon rope network 2. Auto bridge across Little Rapids Cut 3. Air bubbler/flusher system at mainland dock
	B. Neebish Island	1. Do not use west Neebish Channel for winter navigation	1. Snowmobile/foot swing bridge across W. Neebish Channel 2. Ice boom at head of W. Neebish Channel 3. Ice stabilization islands above ice boom

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
II. Island Access transportation (Cont.)	B. Neebish Island (Cont.)		4. Ice stabilization nylon rope network above ice boom 5. Air bubbler system below W. Neebish Channel 6. Preventive icebreaking below W. Neebish Channel 7. Ferry modifications 8. New icebreaking ferry 9. Auto bridge across West Neebish Channel
	C. Lime Island	1. Modified airboat or air cushion vehicle	1. Air cushion vehicle 2. Snowmobile route to Drummond Island 3. Aerial cable chair lift 4. Security system installation on island & wintertime housing of islanders on mainland

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
II. Island Access Transportation (Cont.)	C. Lime Island (Cont.)		5. Aircraft/helicopter stationed on island 6. Icebreaking tug at island
	D. Drummond Island	1. Monitor ferry operation to determine if winter operations impact on ferry operations and to what extent during post authorization	1. Ferry modification 2. New icebreaking ferry 3. Icebreaking tug to assist ferry
	E. All Four Islands	1. Implement island transportation contingency plans	1. Air cushion/auto ferry vehicle to service all four crossings as scheduled & operated by a non-Federal entity

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
III. Potential Ice Jams & Flooding	A. Little Rapids Cut	1. Ice navigation boom & ice stabilization islands 2. Relocation of Soo Sewage Treatment Plant effluent outfall 3. Water level gauges/ flood warning system	
	B. West Neebish Channel	1. Water/level gauges/ flood warning system	
IV. Vessel Movement	A. Tight Turns: Whitefish Bay (Birch Point Turn) Middle Neebish Chan. Angle Course 5 & 6 Angle Course 6 & 7 Angle Course 7 & 8 Angle Course 8 & 9 Lime Island Turn	1. Air bubbler systems 2. Icebreaking assistance	1. Channel clearing device 2. Minimum vessel ice operation capabilities 3. Straightening of channel alignment
	B. Balance of St. Marys River System	1. Maintain vessel tracks 2. Icebreaking assistance 3. Ice Navigation Center/ ice forecasts 4. Vessel convoys 5. Dredging Middle Neebish 6. Vessel traffic control/ monitoring system	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. MARYS RIVER (Cont.)			
V. Shoreline Areas near Navigation Channels	A. Shoreline Erosion	1. One-time shoreline damage compensation or shoreline protection 2. Vessel Speed Control	1. Rubble wall shore protection 2. Gabion basket and/or blanket 3. Concrete walls 4. Sheet pile wall
	B. Dock Damage	1. One-time shore structure compensation 2. Vessel Speed Control	1. Pile clusters 2. Removable docks 3. Ice resistant dock construction
VI. Pilot Access	Detour	1. Replace existing pilot transfer boat with icebreaking tug	1. Helicopters
VII. Power Generation	A. Frazil ice entering Soo Edison Power Plant	1. Maintain stable ice cover on St. Marys River upstream of Power Canal	
	B. Potential flood damage to Edison Sault power facility	1. Preventative icebreaking downstream 2. Ice stabilization structures downstream to minimize ice jams (booms)	
VIII. Other St. Marys River Problems in General	A. Lack of all-weather aids to navigation	1. Mini LORAN-C 2. Radar Transponder Beacons 3. Fixed navigation lights	
	B. Oil Spills	1. Same as L. Superior, para. I., E.	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE MICHIGAN			
I. Open Lake	Same as Lake Superior, paragraph I.	Same as Lake Superior, paragraph I.	
II. Harbors	Same as Lake Superior, paragraph II.	Same as Lake Superior, paragraph II.	Same as Lake Superior, paragraph II.
III. Green Bay and Grand Traverse Bay	A. Vessel Movement through Ice Rafting and Windrows	1. Ice breaker assistance 2. Ice Navigation Center 3. SLAR	
	B. Ice & Weather Information Operations for Shippers	1. Same as Lake Superior, para. I., B	
	C. Lack of all-weather aids to navigation	1. Mini LORAN-C 2. Radar Transponder Beacons 3. Fixed navigation lights	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE HURON			
I. Open Lake	Same as Lake Superior, paragraph I.	Same as Lake Superior, paragraph I.	
II. Harbors	Same as Lake Superior, paragraph II.	Same as Lake Superior, paragraph II.	Same as Lake Superior, paragraph II.
III. Saginaw Bay	A. Vessel movement through ice rafting and windrows	1. Icebreaker assistance 2. Ice Navigation Center 3. SLAR	
	B. Lack of all-weather aids to navigation	1. Mini LORAN-C 2. Radar Transponder Beacons 3. Fixed navigation lights	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. CLAIR - DETROIT RIVER SYSTEM			
I. Potential Ice Jams and Flooding	Broken Lake Huron ice filling St. Clair River	1. Ice booms at the heads of St. Clair & Detroit Rivers with navigation openings 2. Water Level Monitoring System 3. Ice Monitoring System	1. Ice stabilization nylon rope network/islands/fence/cells (Model Study Sch.-FY 79)
II. Shorelines	Shore erosion and dock damage	1. Same as St. Marys River, paragraphs V., A. and B.	1. Same as St. Marys River, paragraphs V., A. and B.
III. Ferry Crossings	Harsens Island, St. Clair/Courtright, Roberts Landing/Port Lambton, Marine City/Sombra	1. Ice control structure at the heads of St. Clair and Detroit Rivers with navigation openings	
IV. Pilot Access	Detroit	1. Replace existing pilot transfer boat with ice-breaking tug	
V. Other Problems in General	A. Same as St. Marys River, para. VII., A., B.		
	B. Maintain natural ice retardation effects	1. Compensating Works vicinity of Stag Island (St. Clair R.) & Peach Island (Detroit River)	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE ERIE			
I. Open Lake	Same as Lake Superior, paragraph I.	Same as Lake Superior, paragraph I.	
II. Harbors	Same as Lake Superior, paragraph II.	Same as Lake Superior, paragraph II.	Same as Lake Superior, paragraph II.
III. Pelee Passage	A. Vessel Movement through shifting ice conditions	1. Maintain vessel tracks 2. Icebreaking assistance 3. Ice Navigation Center 4. Aircraft overflights	1. Vessel convoys
IV. Buffalo Harbor & entrance to Welland Canal	A. Vessel Movement through shifting ice, windrowing and rafting ice	1. Icebreaker assistance 2. Ice Navigation Center 3. Aircraft overflights 4. SLAR 5. Ice booms (Buffalo Harbor)	1. Vessel convoys

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
WELLAND CANAL			
U.S. - Canadian Coordination	Provision of improvement necessary for year-round navigation	Coordination with Canada through Department of State	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
LAKE ONTARIO			
I. Open Lake	Same as Lake Superior, paragraph I.		
II. Harbors	Same as Lake Superior, paragraph II.		

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. LAWRENCE RIVER			
I. St. Lawrence River U.S. Navigation Locks (Eisenhower & Snell)	Provide winter operation capabilities		
	A. Ice removal from mitre gates and operating equipment	Steam thawing - install heating elements	
	B. Unobstructed operation of mitre gates	Install bubbler-flushing system behind each gate (completed)	
	C. Prevent lock wall icing	Lock wall coatings - mechanical removal	1. Steam/electric sawing
	D. Prevent floating ice from entering locks	Install ice control devices at upstream lock entrances (air curtain) (completed at Snell, underway at Eisenhower)	
	E. Removal of floating ice from locks	Install ice flushing ports in locks (underway at Eisenhower)	1. Install flushing ports in downstream gates 2. Special lock clearing craft

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. LAWRENCE RIVER (Cont.)			
II. St. Lawrence R. - Canadian Locks (St. Lambert, St. Catherine, Beauharnois, Melocheville, Iroquois)			
III. Maintain** stable ice cover & prescribed levels and flows in critical channel reaches transiting ice booms & ice jams	A. Ogdensburg - Prescott Area*	1. Installation of navigation opening in existing ice boom 2. Addition of ice stabilization structures	1. Installation of gate in existing boom
	B. Galop Island Area*	1. Installation of navigation opening in existing ice boom	1. Installation of gate in existing boom
	C. Ogden Island Area*	1. Installation of ice booms	1. Dredging
	D. St. Regis Island	1. Installation of ice booms	1. Dredging
	E. Beauharnois Canal (all-Canadian)	1. Entrance boom modifications with navigation opening 2. Improve existing booms in Canal (traverse & longitudinal)	1. Booms with gated opening 2. Use of waste heat 3. Dredging

NOTES:
*Model Study underway
**Canadian co-participation required

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. LAWRENCE RIVER (Cont.)			
IV. Other St. Lawrence River Problems in General	A. Lack of all-weather aids to navigation	1. Develop Precise All-Weather Navigation System (PAWNS) 2. Additional fixed navigation aids in selected locations	1. Deployment of ice buoys at selected locations 2. RACONS
	B. Icebreaking	1. Icebreakers 2. Icebreaking tugs	1. Use of waste heat
	C. Channel Clearing	1. Design and construct channel clearing craft	1. Use of waste heat
	D. Provide ice & weather information to shippers	1. Ice and weather data collection program a) Vertical aerial photography b) Aerial reconnaissance c) Recording thermographs d) Water level gages e) Ice thickness studies f) Freeze-up forecasting g) Breakup forecasting h) Ice marking & monitoring	
	E. Shore erosion and structure damage	1. Same as St. Marys River, paragraph V., A. and B. 2. Vessel speed restrictions	

TABLE 1 (Cont.)

ENGINEERING PROBLEMS/ALTERNATIVE SOLUTIONS

General Problem Area	Specific Problem	Proposed Solution	Other Measures Considered
ST. LAWRENCE RIVER (Cont.)			
V. Island transportation considerations	Thousand Islands area-Grindstone Island	1. Provide air cushion vehicle with support facilities	1. Ice boat 2. Start ferry service 3. Construct an auto bridge between Grindstone & Clayton 4. Start a helicopter service 5. Use alternate route via Thousand Island Bridge
VI. Pilot Access	Cape Vincent	1. Replace existing pilot transfer boats with icebreaking tugs	1. Helicopter

The greatest possible range of solutions to a given problem was examined to determine the most feasible solution. The proposed solution(s) and other measures considered are summarized in the "Engineering Problems/Alternative Solutions Tables." Each problem was assigned individually or jointly to one or more U.S. Government agencies to provide the technical analysis of possible solutions and recommendations for thhe most feasible solution(s). The agencies which were assigned these responsibilities were:

U.S. Army Corps of Engineers, Detroit District
U.S. Coast Guard
U.S. Army Cold Regions Research and Egineering Laboratory
St. Lawrence Seaway Development Corporation
Maritime Administration
National Oceanic and Atmospheric Administration, Great Lakes Engineering Research Laboratory
U.S. Fish and Wildlife Service

The development and examination of feasible solutions which led ultimately to the recommended solutions(s) to a given problem included technical and economic inputs as well as possible environmental and social impacts to the extent they were known at that time. Where possible, the choice of recommended solutions to a problem and/or the construction details and methods were altered to accommodate these known environmental and social impacts. As possible enviromental and social impacts are identified, improved solutions would be sought.

PRIOR AND ON-GOING STUDIES AND REPORTS

Summaries of publications and reports being used as references or that are directly related to the extended season navigation study, including documents prepared under the Demonstration Program, are presented in the following list:

1. Survey Report on Great Lakes and St. Lawrence Seaway Navigation Season Extension (Feasibility Study - 1969). This study, authorized by Section 304 of the River and Harbor Act of 1965, is a preliminary investigation outlining the existing and prospective commerce and vessel fleet, difficulties attending winter navigation, methodology considered to extend the navigation season, and general costs and benefits derived from winter navigation on the Great Lakes. It concludes that future extension of the navigation season is economically justifiable, based on preliminary cost figures. A large benefit will accrue to the movement of overseas general cargo. It stresses that adequate vessel design and preparation, to provide a reasonable degree of independent ice operation, is an essential requisite to successful ice navigation. The study presents a recommendation for further study.

2. Great Lakes-St. Lawrence Seaway Navigation Season Extension Demonstration Program. This program, authorized by Section 107(b) of the River and Harbor Act of 1970 and directed by the "Winter Navigation Board", is aimed at demonstrating the practicability of extending the navigation season on the Great Lakes-St. Lawrence Seaway System. Four annual reports displaying the annual activities and achievements since 1971 have been prepared by the Board. A Special Status Report on the first three years of the program was sent to Congress in February 1975. Another report on the findings and conclusions of the Demonstration Program through the winter 1975-76 was completed in May 1976. The overall conclusion is that the practicability of navigation season extension on the upper four

Great Lakes system has been successfully demonstrated. However, further demonstration activities should be conducted in the St. Lawrence River portion of the system, and certain problem areas in the Great Lakes portion need further investigation. The Final Demonstration Report submitted by the Division Engineer, North Central Division, to the Chief of Engineers on 26 September 1979.

3. Great Lakes-St. Lawrence Seaway Navigation Season Extension, Interim Feasibility Study (House Document No. 96-181). This study report was forwarded on 3 August 1979 to the Congress, by the Secretary of the Army for its information. It consists of three volumes and was prepared by the Detroit District, U.S. Army Corps of Engineers. Volumes II and III contain supporting data to the main report (Volume I). The study recommends the feasibility of extended season navigation on the upper four Great Lakes, Lakes Superior, Michigan, Huron, and Erie, and their connecting channels, to 31 January, plus or minus two weeks, using existing and proven operational measures.

4. Feasibility Study - Sault Ste. Marie Lock System Evaluation. The purpose of this study is to reevaluate the capacity and serviceability of the existing system in relation to the most probable future conditions and to determine the best judgment concerning the future of the lock system. This study, under the authority of the River and Harbor Act of 1909, has been deferred indefinitely, pending further review. The Detroit District, U.S. Army Corps of Engineers, has the responsibility for this study.

5. Great Lakes Connecting Channels and Harbors Study. This is a comprehensive survey scope study with a view to determining the advisability of further improvements in the Great Lakes Connecting Channels and Harbors in the interest of present and prospective deep-draft commerce. The Revised Plan of Study was issued in August 1975, and the second issue in May 1978. The study, being conducted by Detroit District, U.S. Army Corps of Engineers, is currently scheduled for completion in Fiscal Year 1984. The authority for this study evolves from two separate resolutions of the Senate Committee

on Public Works and a resolution of the Committee on Public Works and Transportation, House of Representatives.

6. Great Lakes Basin Framework Study. This study was conducted by the Great Lakes Basin Commission. There are 24 appendixes to the Framework Study, each of which describe studies of a specific area associated with economic, social, environmental, and physical fields related to the Great Lakes Basin. Appendix C-9 to this report relates to commercial navigation on the Lakes. It concludes that the Great Lakes-St. Lawrence River system is a low cost transportation facility essential to the economic vitality of the Great Lakes Region that is presently underutilized. However, the capacity of the existing Welland Canal and Seaway may be reached by 1990. It recommends every effort should be made to improve the efficiency of the present system and every reasonable effort should be made to extend the length of the navigation season. The basis for the Framework Study: exerpts from Section 204, Public Law 89-90, and from Water Resources Council policy statement issued July 22, 1970.

7. Lake Erie - Lake Ontario Waterway Study. This study considers the implementation of a five-lock United States waterway connecting the two lakes. A feasibility report, dated October 1973, was prepared by Buffalo District, U.S. Army Corps of Engineers. The report concluded the waterway was environmentally and technically feasible but was not economically justified based solely on transportation savings. Future consideration will be given this project from a systems standpoint and will be included in an upcoming lock study. This study was authorized by series of resolutions: of the Committee on Public Works, U.S. Senate, 6 May 1958; Committee on Publiic Works, House of Representatives, 16 July 1958; Committee on Public Works, House of Representatives, dated 24 August 1961, and 11 December 1969.

8. Great Lakes Harbors Study. The final report, dated November 1966, together with 38 interim reports, contain the economic and physical data and analyses used to justify improvements made during the late 1950's and early 1960's. Included are recommendations that 30 harbors be improved and one harbor be built to provide a 27-foot safe draft depth commensurate with the 27-foot depths provided in the connecting channels, the Weiland Canal, and the St. Lawrence River. The report was submitted in response to resolution by the Committee on Public Works, United States Senate, adopted 18 May 1956, and by the Committee on Public Works, House of Representatives, United States, adopted 29 June 1956.

9. Great Lakes Region Inventory Report National Shoreline Study. This study, dated August 1971, was prepared by the North Central Division, U.S. Army Corps of Engineers, and is an appraisal investigation to define the order of magnitude of the region's shore erosion problems as part of the total national study. The report describes the physical and economic character of the Great Lakes Region and summarizes the shoreline condition, uses, ownership, flooding, and erosion areas. The report also suggests suitable types of erosion protection and provides preliminary cost estimates for such protection. This report was prepared under the Authority of Section 106 of Public Law 90-483 (August 13, 1968).

10. The Great Lakes and St. Lawrence Seaway Study of Insurance Rates. As part of the overall study on navigation season extension, a report on insurance rates was prepared by the Maritime Administration of the U.S. Department of Commerce. The report, dated June 1972, details the physical risk, risk management, and insurance costs attendant to an extension of the navigation season. The study examines the factors that inhibit an extension of the season, together with methods of countering these factors and legislative recommendations to implement a government program to provide marine insurance. This study was authorized by Section 107(c) of the River and Harbor Act of 1970. The results of the June 1972 report were

updated in June 1979; the conclusions of this study indicate insurance rates did not inhibit season extension.

11. <u>Mississippi River Year-Round Navigation Study</u>. This study addresses the advisability, practicability, means, and economic justification for providing year-round navigation on the upper Mississippi River. A preliminary feasibility report was prepared in September 1973 by the North Central Division, U.S. Army Corps of Engineers. The preliminary findings recommend that further study be undertaken to extend winter navigation on the upper Mississippi to provide a year-round season to Burlington, Iowa, and 40 week season upstream to Cassville, Wisconsin. An Economic Analysis Draft was done in June 1979. This study was authorized by the Committee on Public Works, U.S. Senate, 6 April 1966, and Resolution dated 5 May 1966, House of Representatives.

12. <u>Great Lakes Water Levels Study</u>. This study, conducted under the auspices of the International Joint Commission, evaluates various alternative regulation schemes for the Great Lakes-St. Lawrence Seaway System, with corresponding benefit-cost analyses for each plan. There has been published a main report, entitled "Regulation of the Great Lakes Water Levels, 7 December 1973", which includes seven supporting appendixes: (A) Hydrology and Hydraulics, (B) Lake Regulation, (C) Shore Property, (D) Fish, Wildlife, and Recreation, (E) Commercial Navigation, (F) Power, and (G) Regulatory Works. Appendix E, Commercial Navigation, assesses the potential benefit or loss to shipping resulting from changes in lake level regimes and evaluates the economic effects on navigation resulting from regime changes that would take place under selected regulation plans. A new report is being done under two new References, 1977; no data is yet available. The report was prepared under the Reference to the International Joint Commission of October 7, 1967.

13. Navigation Season Extension Studies-Gulf of St. Lawrence to Great Lakes. These are a series of yearly reports prepared by the Canadian Marine Transportation Administration, Ministry of Transport, Canada, on the studies of their efforts of winter data collection on the Great Lakes-St. Lawrence System. Included are studies on ice conditions and thickness, shore observations, hydrometeorological data, ice breaker operations, and operational problems. They are intended to be compared with past and possible future studies pertaining to extending the navigation season.

14. St. Lawrence Seaway Additional Locks Study. This study is to determine the adequacy of the existing locks in the St. Lawrence Seaway and the advisability of their enlargement or augmentation by the construction of additional or duplicate locks, in view of the needs for the present and anticipated heavy volume of commerce using the waterway. The study, being conducted by Buffalo District, U.S. Army Corps of Engineers, is currently scheduled for completion in Fiscal Year 1983. This study was authorized on 15 June 1966 by the Committee on Public Works, U.S. Senate, by a Resolution.

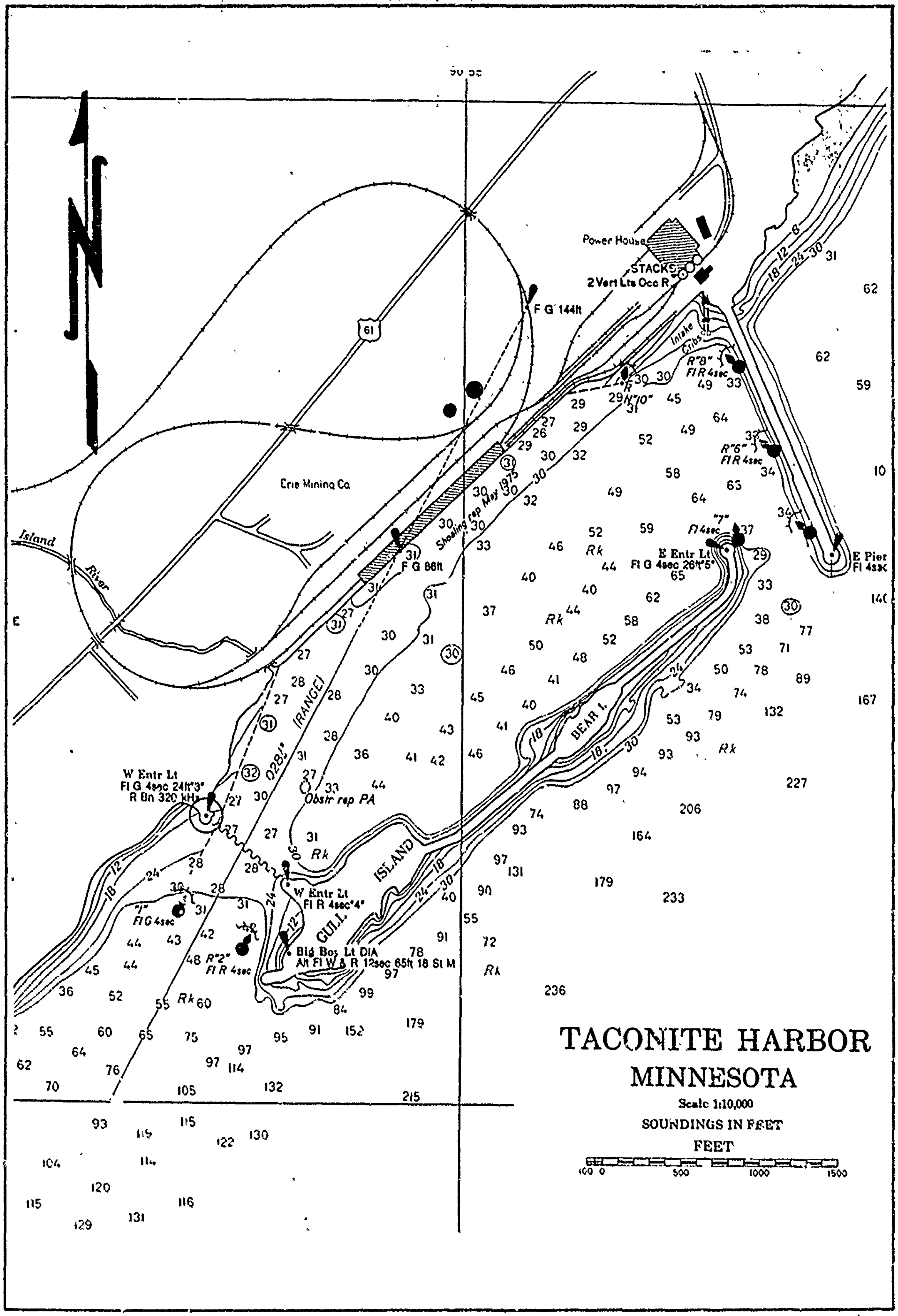
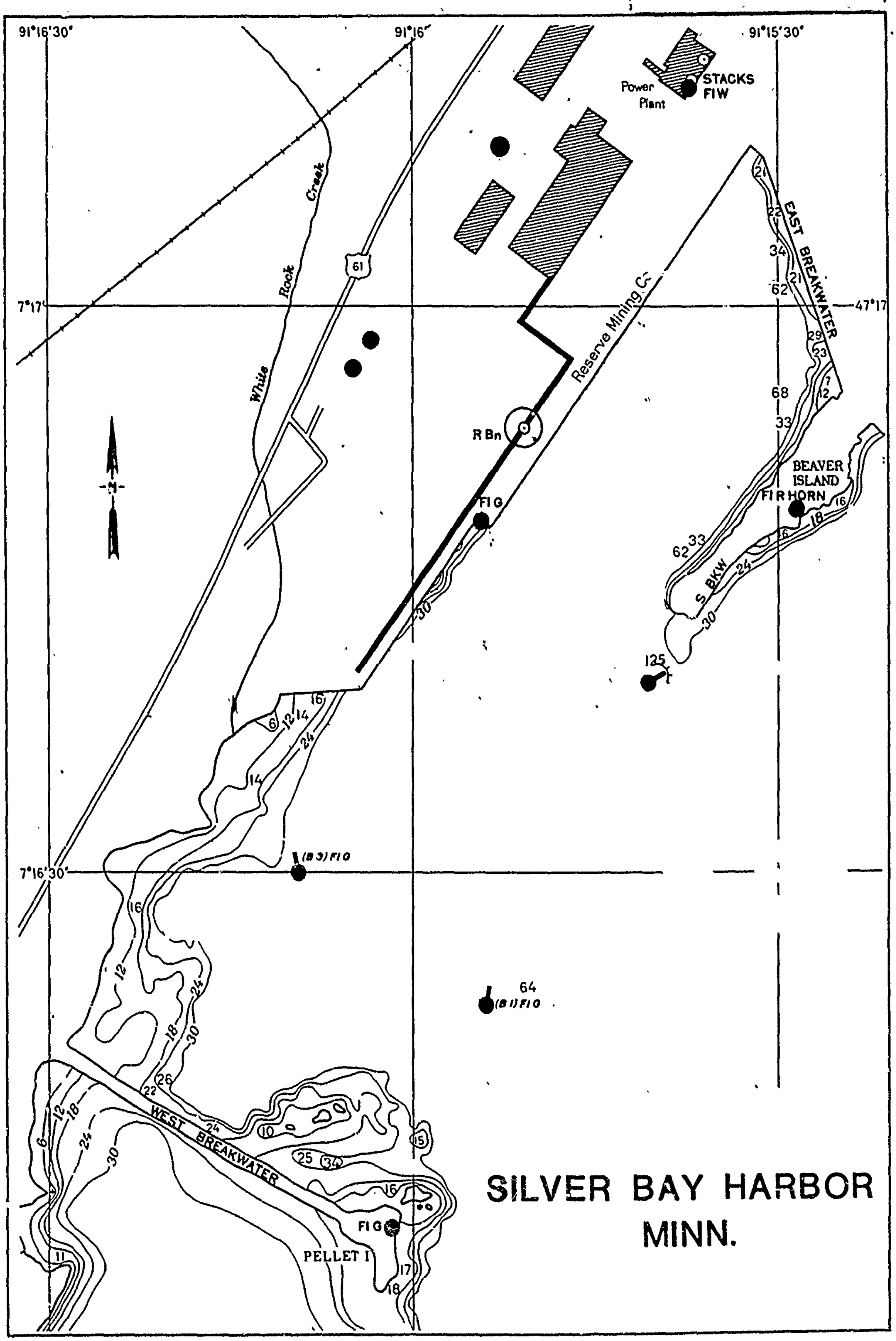

TACONITE HARBOR
MINNESOTA
Scale 1:10,000
SOUNDINGS IN FEET
FEET
Power House
STACKS
2 Vert Lts Occ R
F G 144ft
Erie Mining Co
Island River
Intake Cribs
R"8" Fl R 4sec
N"10"
R"6" Fl R 4sec
"7" Fl 4sec
E Entr Lt Fl G 4sec 26ft 5"
E Pier Fl 4sec
Shoaling rep May 1975
F G 86ft
BEAR I.
W Entr Lt Fl G 4sec 24ft 3" R Bn 320 kHz
Obstr rep PA
W Entr Lt Fl R 4sec 4"
GULL ISLAND
Big Bay Lt DIA Alt Fl W & R 12sec 65ft 18 St M
"1" Fl G 4sec
R"2" Fl R 4sec
028½° (RANGE)
Rk

FIGURE B-1



APP B

FIGURE B-2

Figure 5.1

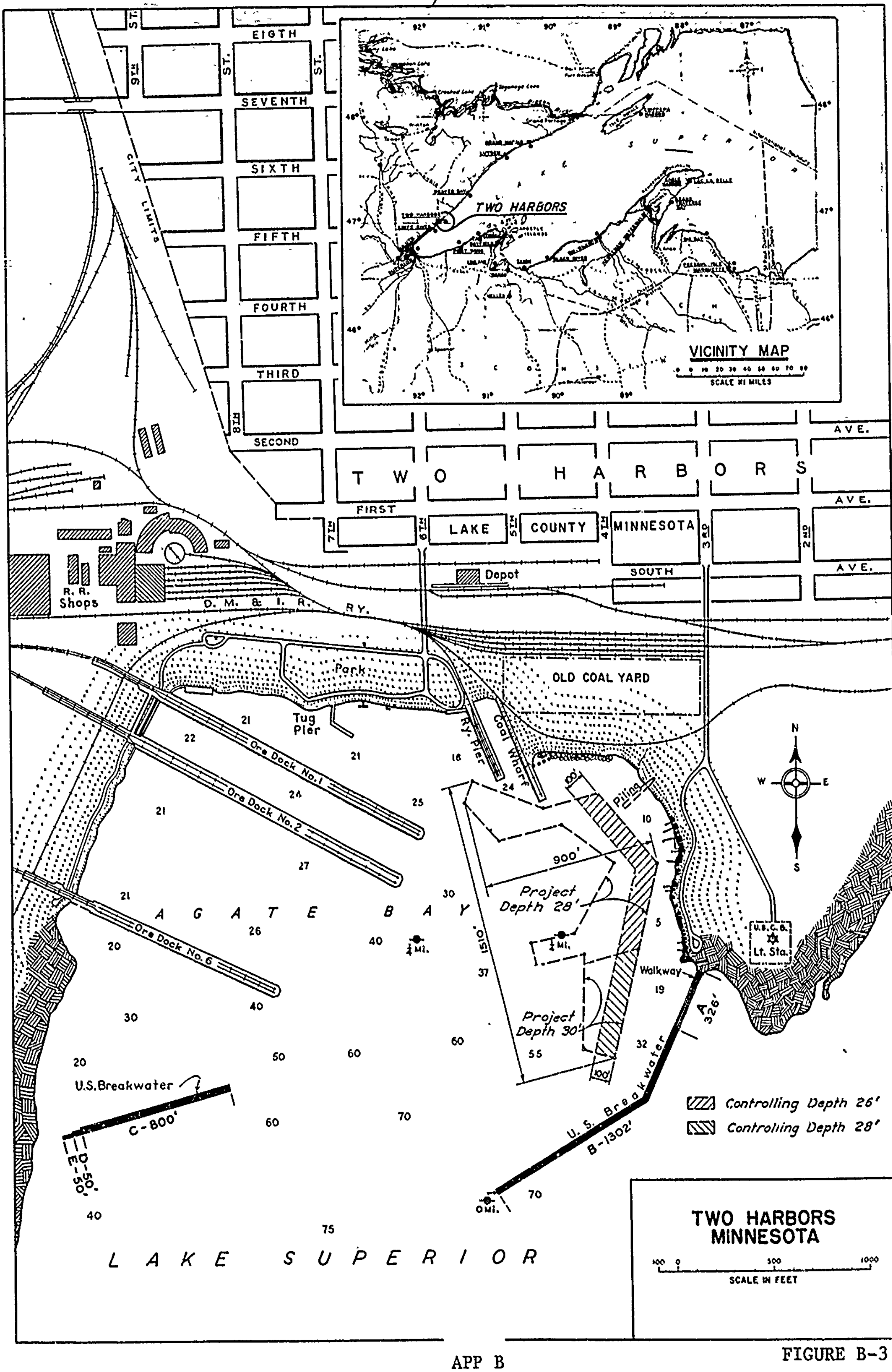
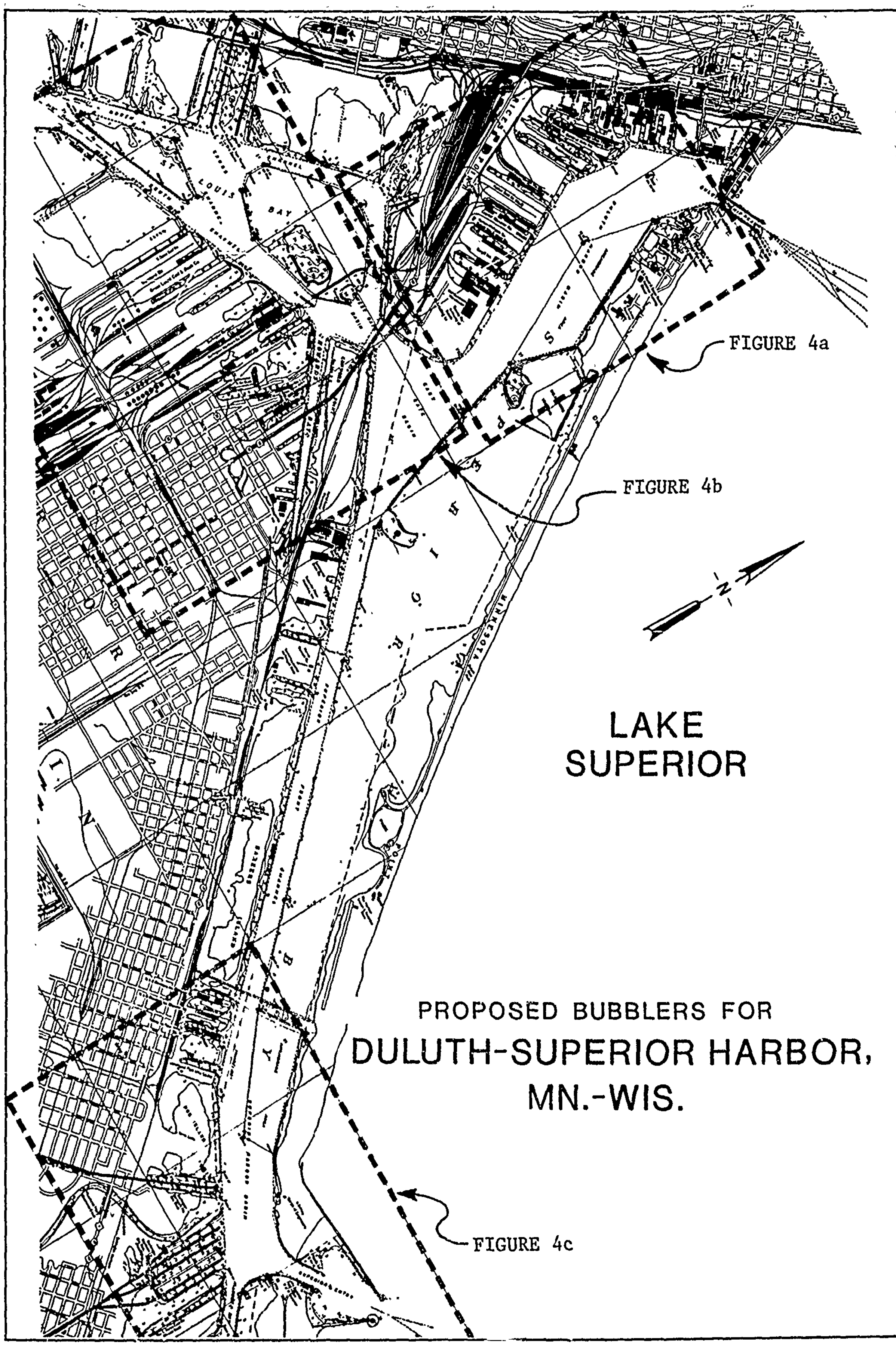
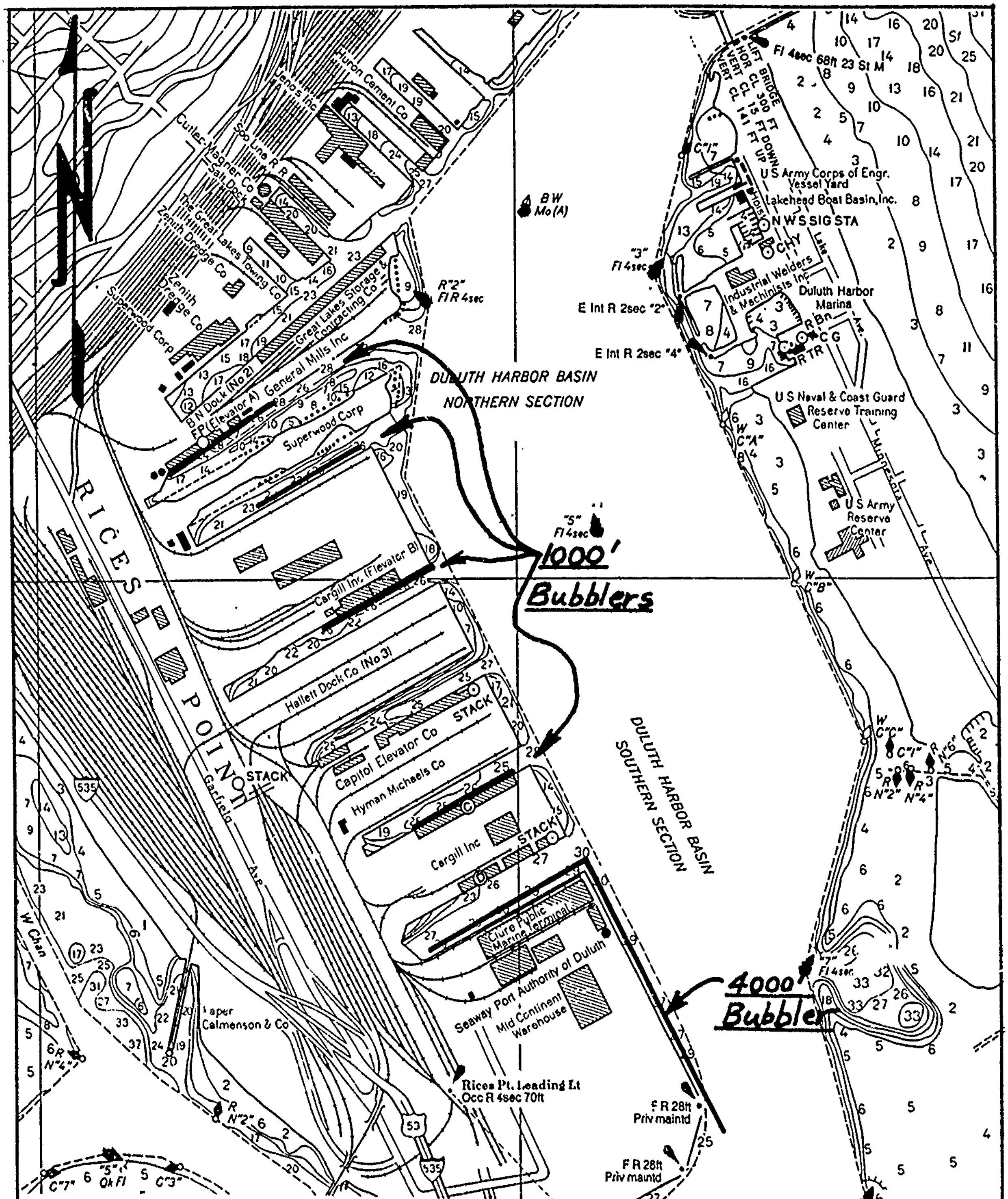


FIGURE B-3



ST LOUIS BAY
FIGURE 4a
FIGURE 4b
N
LAKE SUPERIOR
PROPOSED BUBBLERS FOR
DULUTH-SUPERIOR HARBOR,
MN.-WIS.
FIGURE 4c

APP B



PROPOSED BUBBLERS

DULUTH HARBOR BASIN AREA

FIGURE B-4a

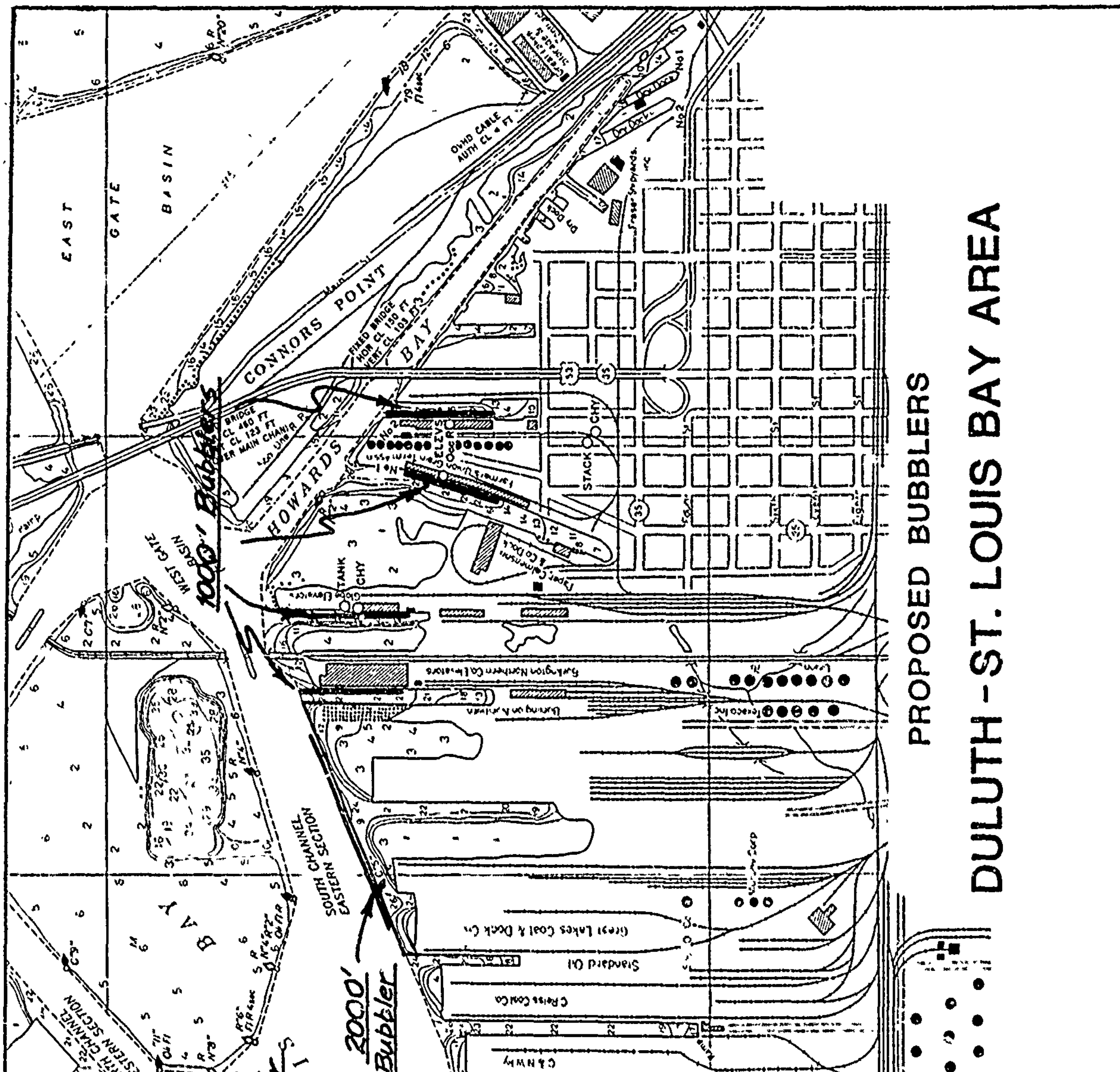

PROPOSED BUBBLERS
DULUTH - ST. LOUIS BAY AREA
1000' Bubblers
2000' Bubbler
4000' Bubbler
EAST GATE BASIN
CONNORS POINT
HOWARDS BAY
WEST GATE BASIN
SOUTH CHANNEL EASTERN SECTION
SOUTH CHANNEL WESTERN SECTION
NORTH CHANNEL WESTERN SECTION
UPPER CHANNEL
Standard Oil
Great Lakes Coal & Dock Co.
Burlington Northern Co. Elevators
STACK CHY
TANK CHY
(RANGE)

FIGURE B-4b

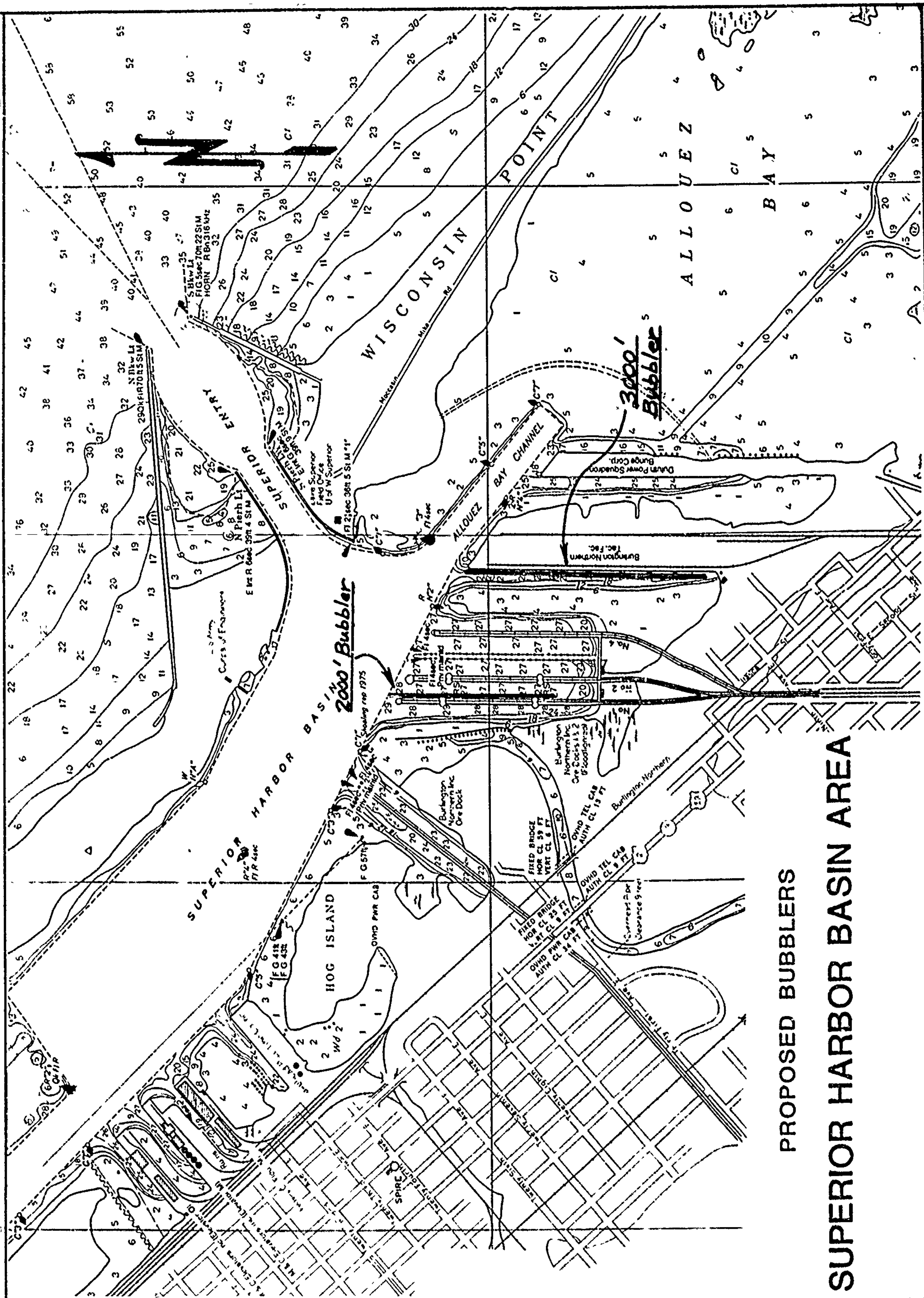
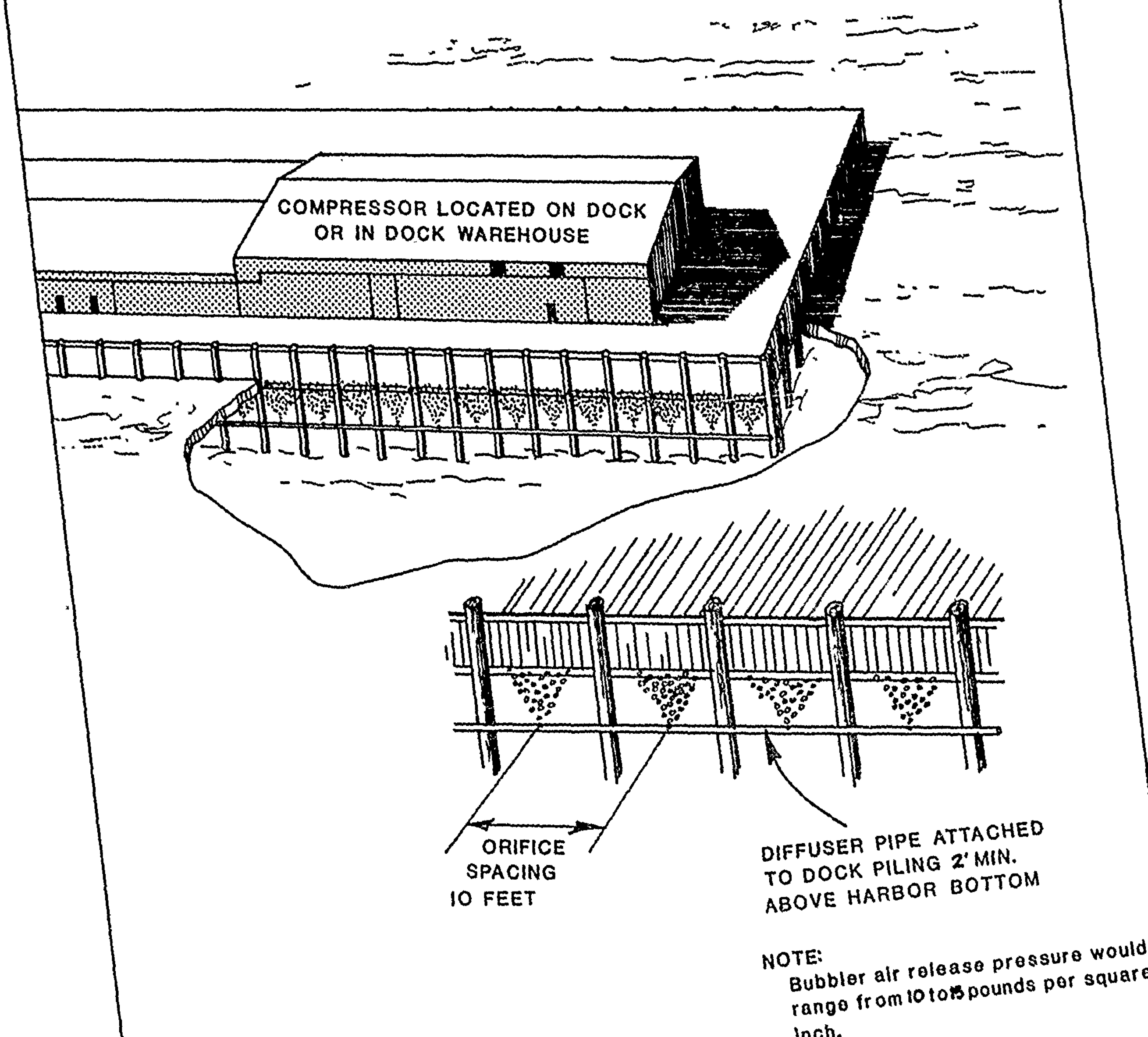
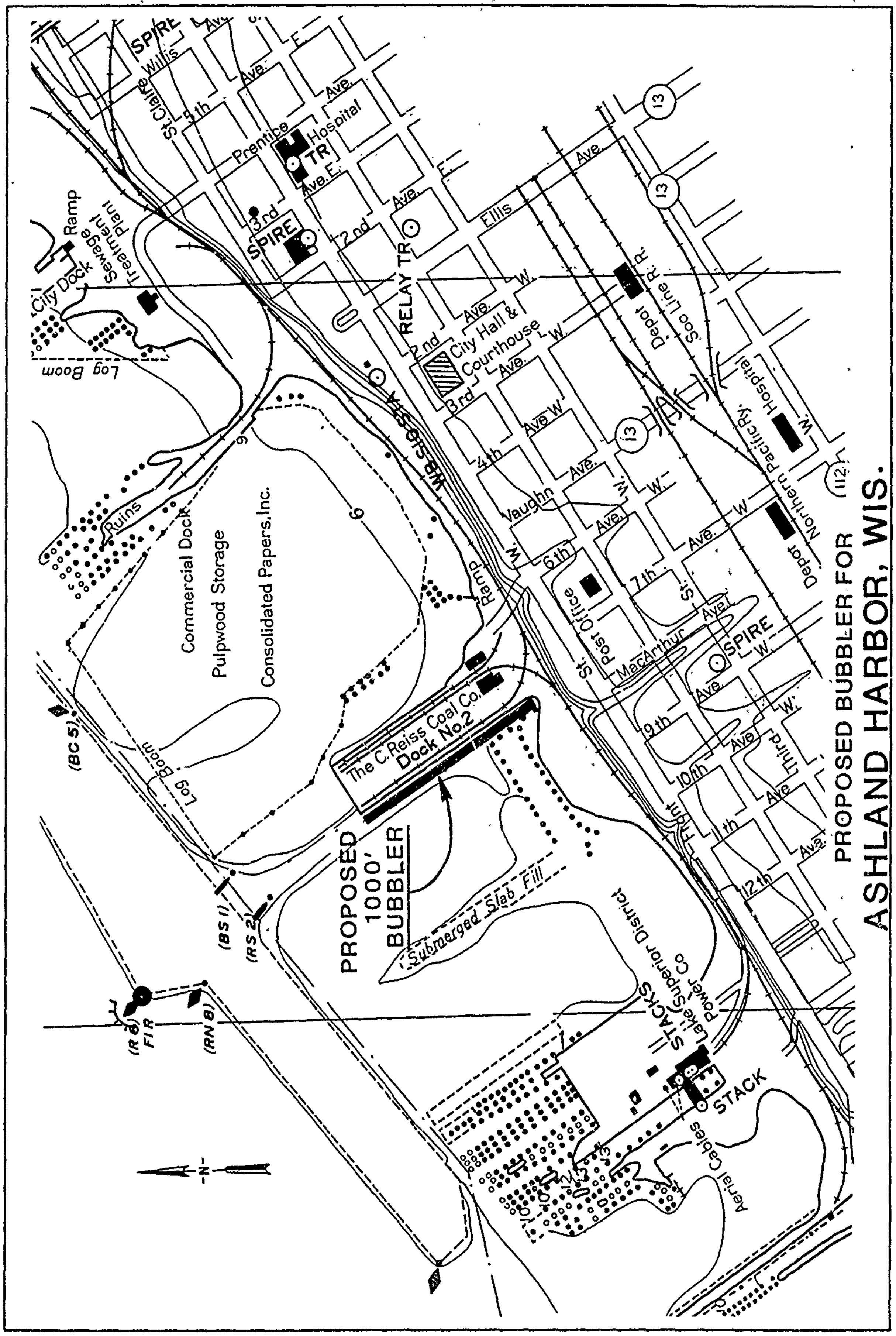

PROPOSED BUBBLERS
SUPERIOR HARBOR BASIN AREA
2000' Bubbler
3000' Bubbler
SUPERIOR HARBOR BASIN
SUPERIOR ENTRY
WISCONSIN POINT
ALLOUEZ BAY
ALLOUEZ BAY CHANNEL
HOG ISLAND
Burlington Northern Inc Ore Dock
Burlington Northern
FIXED BRIDGE
OVHD TEL CAB
OVHD PWR CAB

FIGURE B-4c



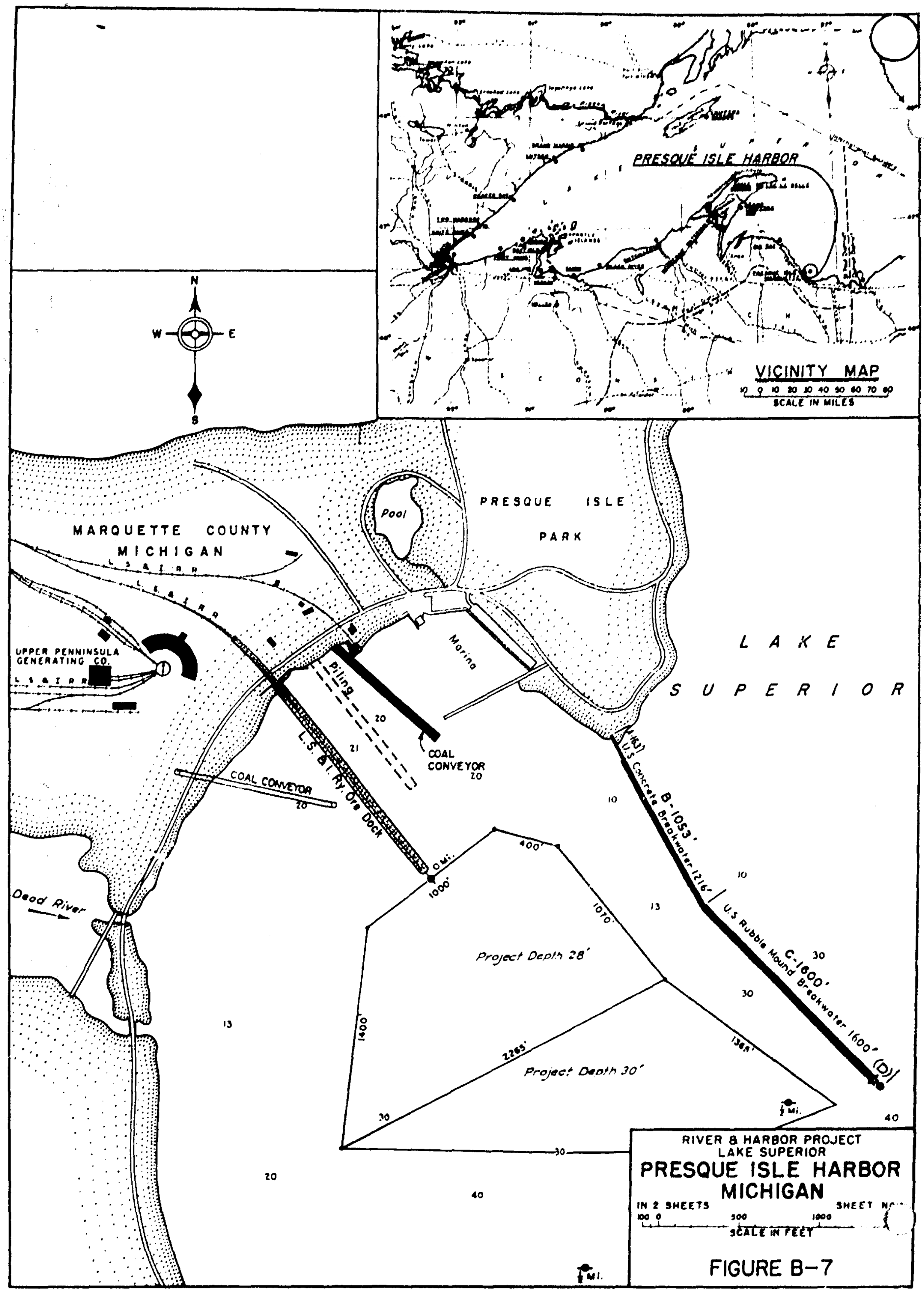
TYPICAL DOCK BUBBLER

FIGURE B-5



APP B

FIGURE B-6


PRESQUE ISLE HARBOR
VICINITY MAP
SCALE IN MILES
N
W
E
S
MARQUETTE COUNTY
MICHIGAN
PRESQUE ISLE
PARK
Pool
Marina
UPPER PENNINSULA
GENERATING CO.
Piling
COAL
CONVEYOR
COAL CONVEYOR
L. S. & I. Ry. Ore Dock
LAKE
SUPERIOR
U.S. Concrete Breakwater 1216'
B-1053'
U.S. Rubble Mound Breakwater 1600'
C-1600'
Project Depth 28'
Project Depth 30'
Dead River
RIVER & HARBOR PROJECT
LAKE SUPERIOR
PRESQUE ISLE HARBOR
MICHIGAN
IN 2 SHEETS
SCALE IN FEET
FIGURE B-7

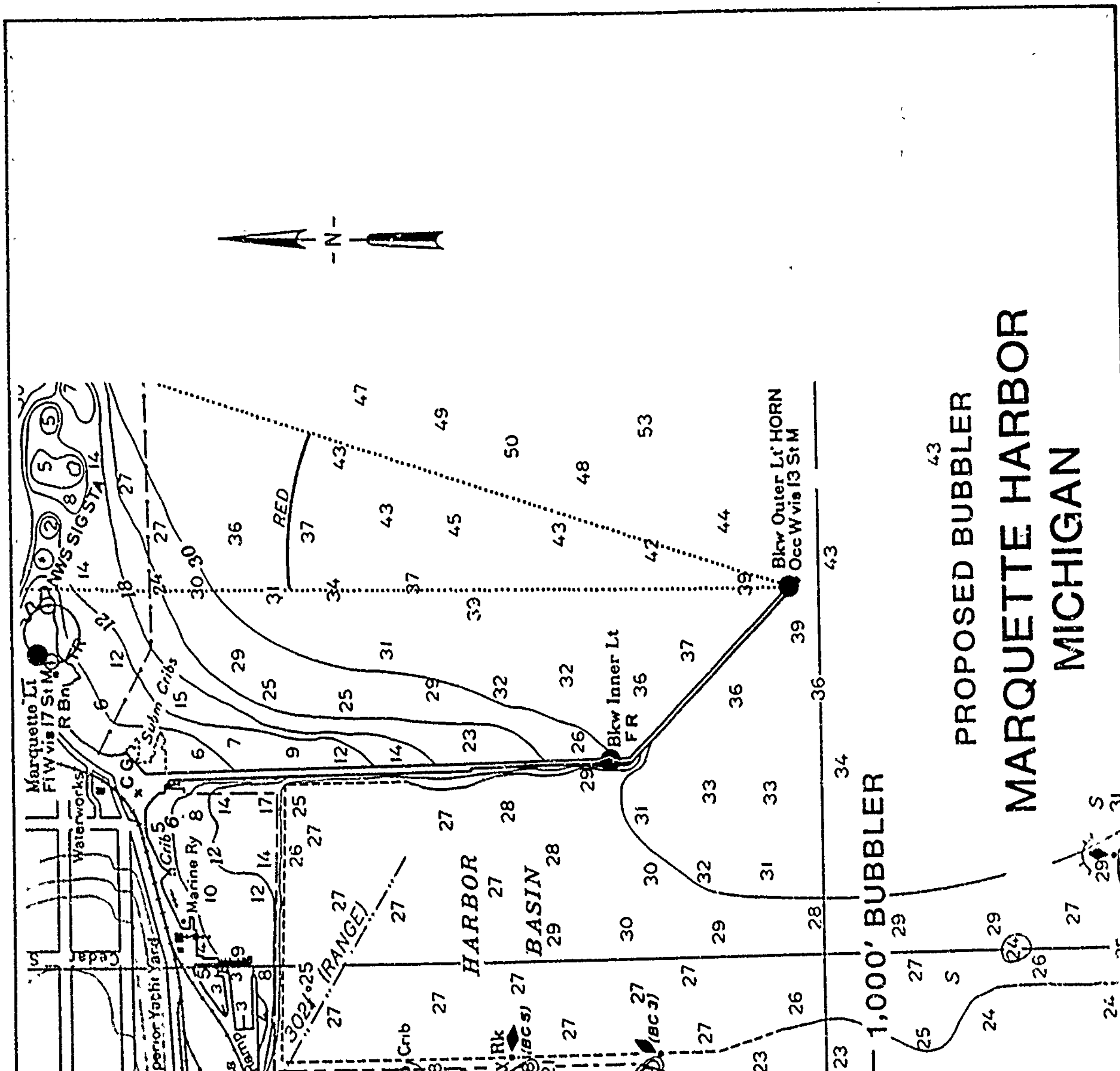
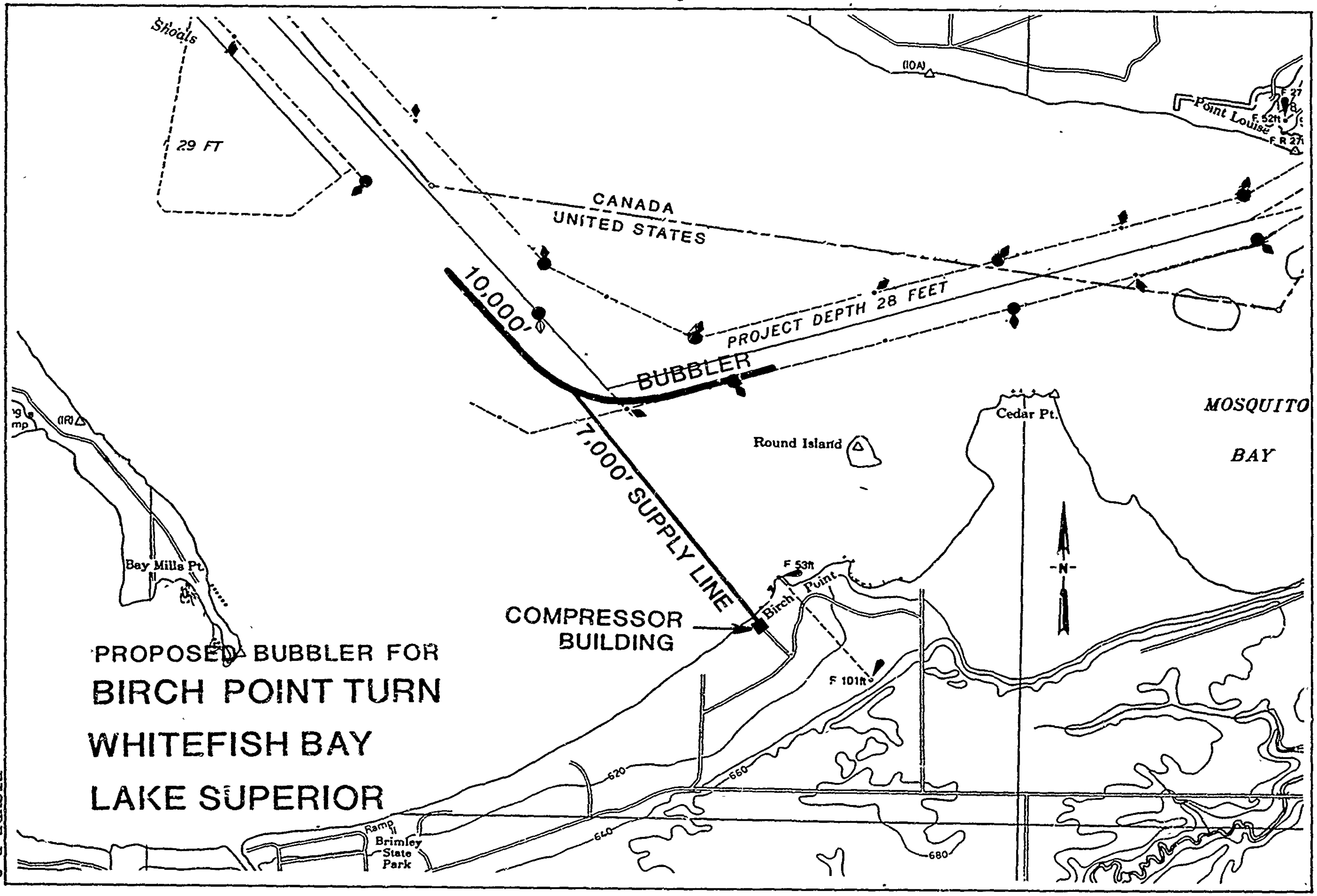
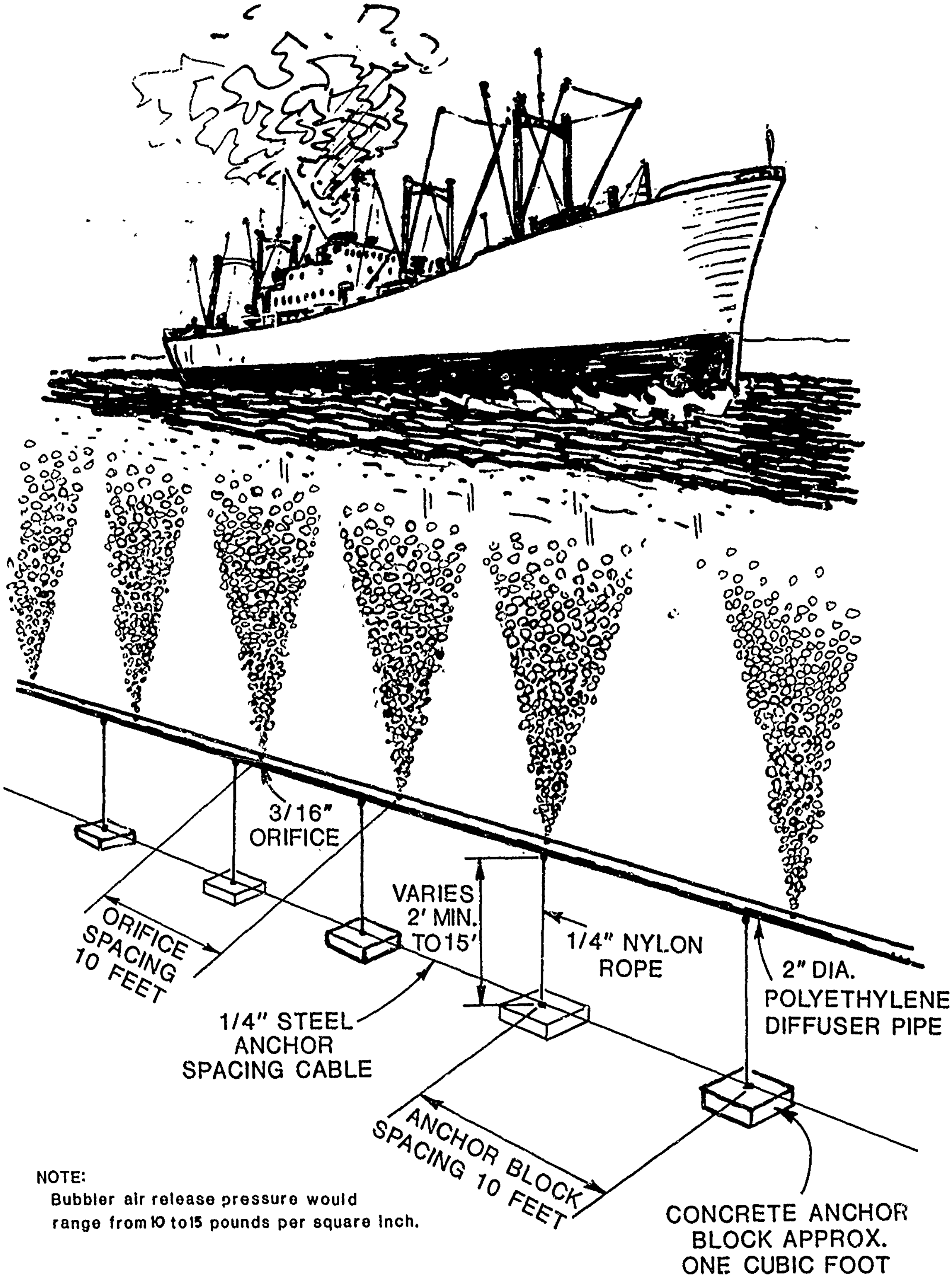

PROPOSED BUBBLER
MARQUETTE HARBOR
MICHIGAN
1,000' BUBBLER
HARBOR
BASIN
HARBOR LINE
Bkw Outer Lt HORN
Occ W vis 13 St M
Bkw Inner Lt
FR
Marquette Lt
FlW vis 17 St M
R Bn
NWS SIG STA
Subm Cribs
RED
Crib
Marine Ry
Waterworks
Lake Superior Yacht Yard
Marquette Dock Co
Coal Dock
Rge Lts
F G
302°25' (RANGE)
Ripley Rk
Marquette Dock Assn.
Campbell Supply Co
Soo Line Ore Dock
International Oil Corp.
Texaco Inc
Spear and Sons, Inc
Shiras Generating Plant
STACK
2 Vert Lts
Fl R F R
R RELAY
Courthouse
City Hall
Post Office
Champion
Division
Quarry Pond
Arch
Ridge
Cedar

FIGURE B-8



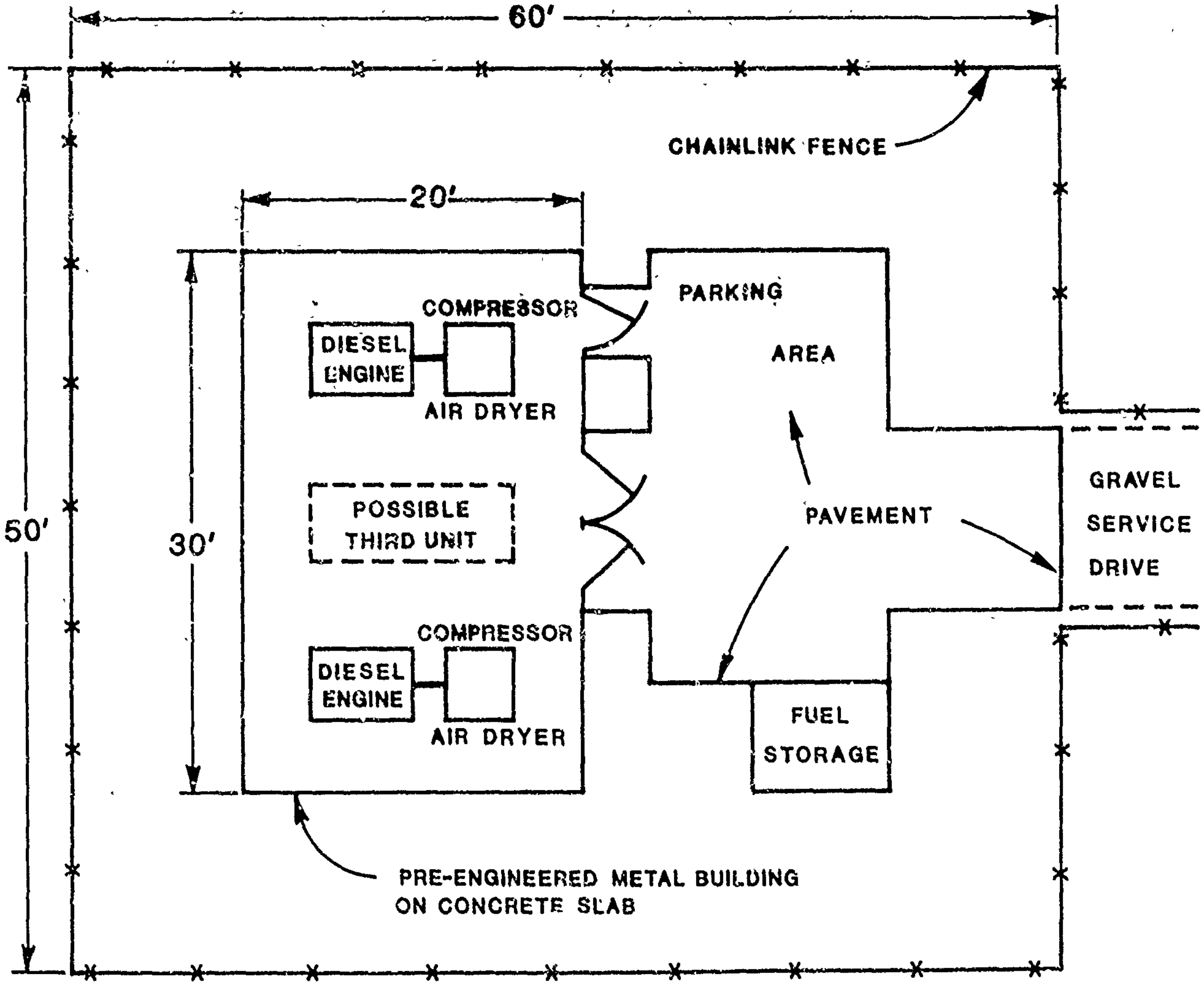
PROPOSED BUBBLER FOR
BIRCH POINT TURN
WHITEFISH BAY
LAKE SUPERIOR
CANADA
UNITED STATES
PROJECT DEPTH 28 FEET
BUBBLER
10,000'
7,000' SUPPLY LINE
COMPRESSOR
BUILDING
Shoals
29 FT
Point Louise
Round Island
Cedar Pt.
MOSQUITO
BAY
Bay Mills Pt.
Birch Point
Brimley
State
Park
Ramp
N
620
640
660
680

FIGURE B-9

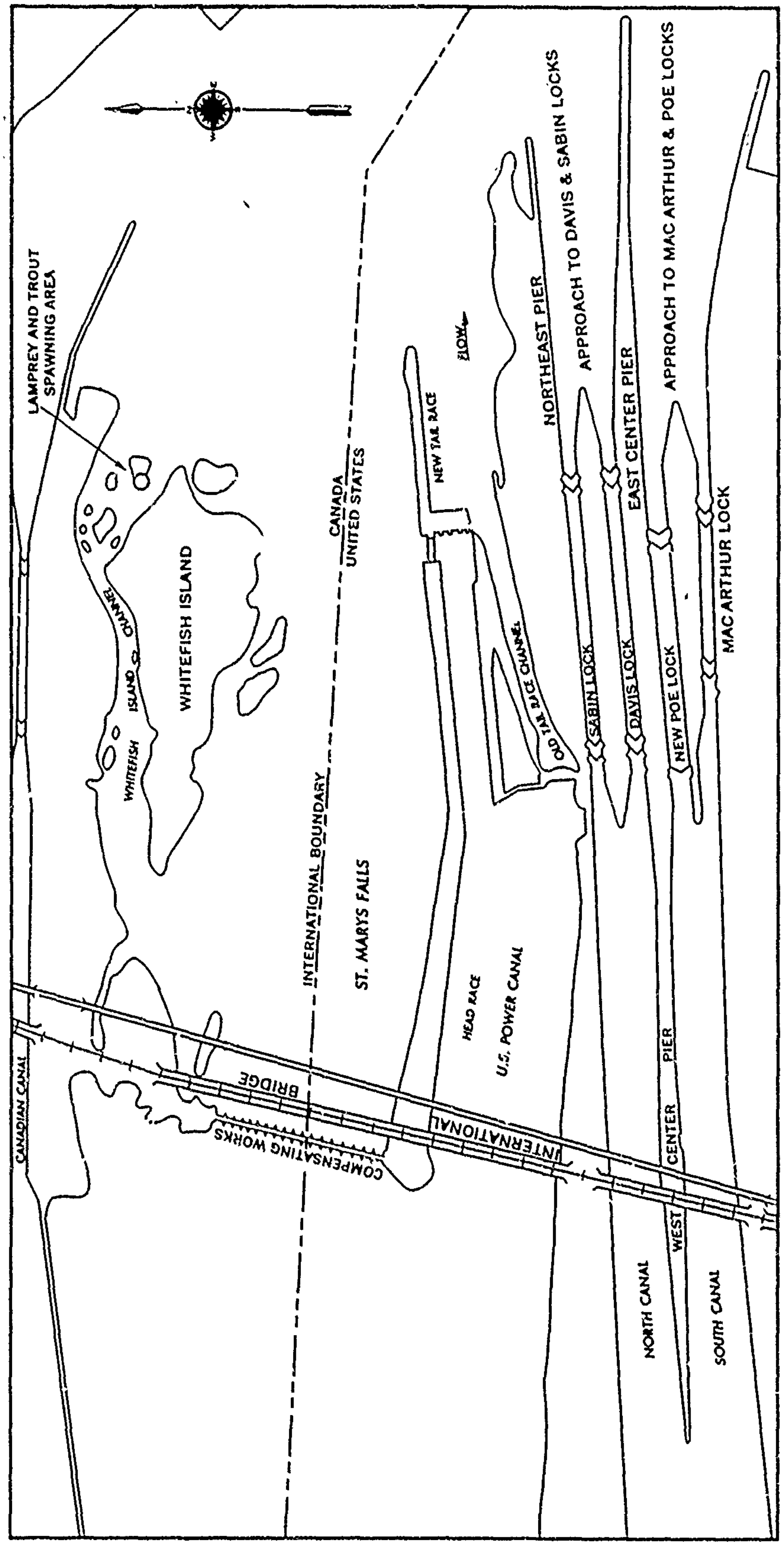


TYPICAL CHANNEL BUBBLER

FIGURE B-10



TYPICAL COMPRESSOR FACILITY



ST. MARYS RIVER
SOO LOCKS

FIGURE B-12

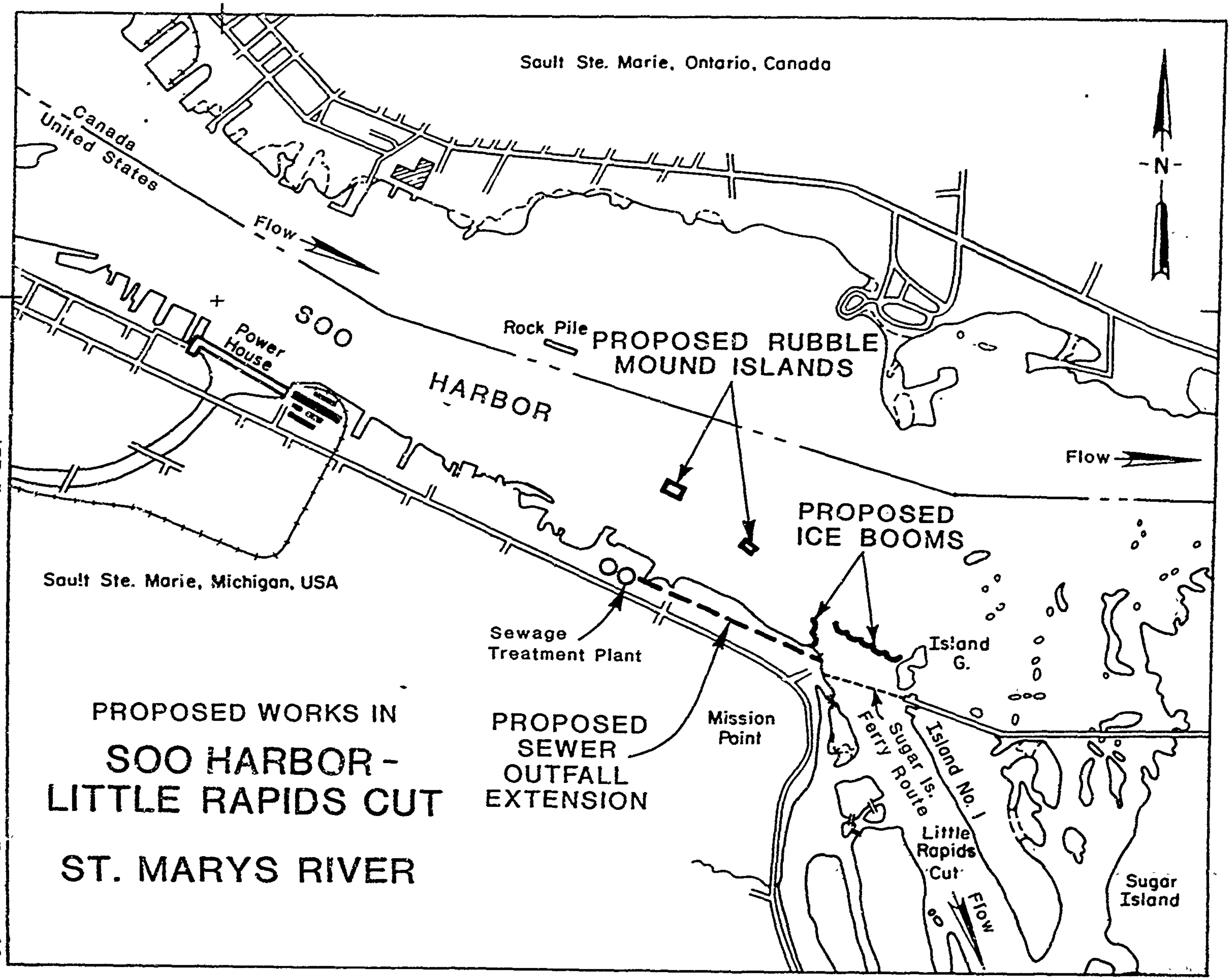

Sault Ste. Marie, Ontario, Canada
N
Canada
United States
Flow
SOO
HARBOR
Power House
Rock Pile
PROPOSED RUBBLE MOUND ISLANDS
Flow
PROPOSED ICE BOOMS
Island G.
Sault Ste. Marie, Michigan, USA
Sewage Treatment Plant
Mission Point
Sugar Is. Ferry Route
Island No. 1
Little Rapids Cut
Flow
Sugar Island
PROPOSED SEWER OUTFALL EXTENSION
PROPOSED WORKS IN
SOO HARBOR - LITTLE RAPIDS CUT
ST. MARYS RIVER

FIGURE B-13

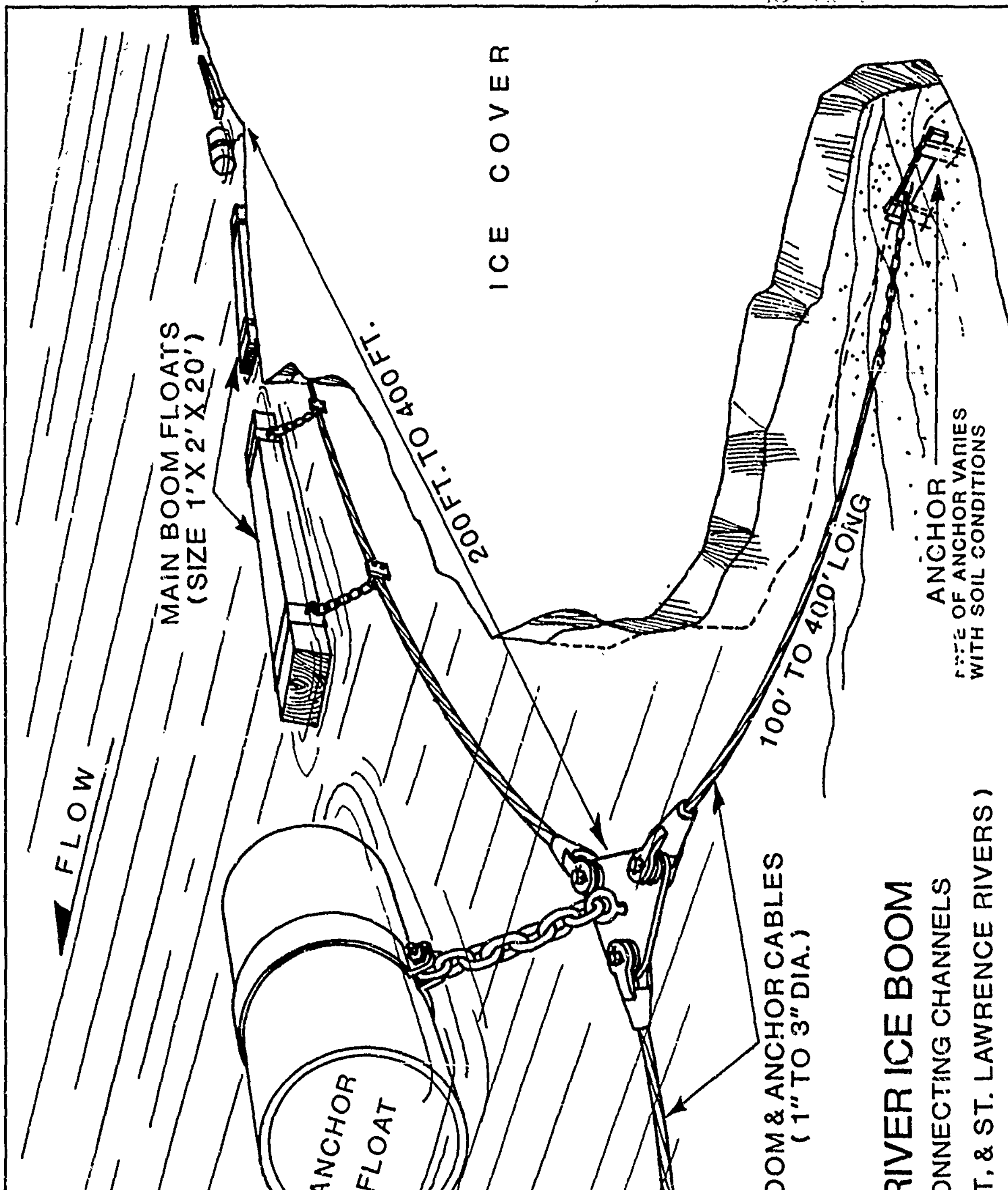
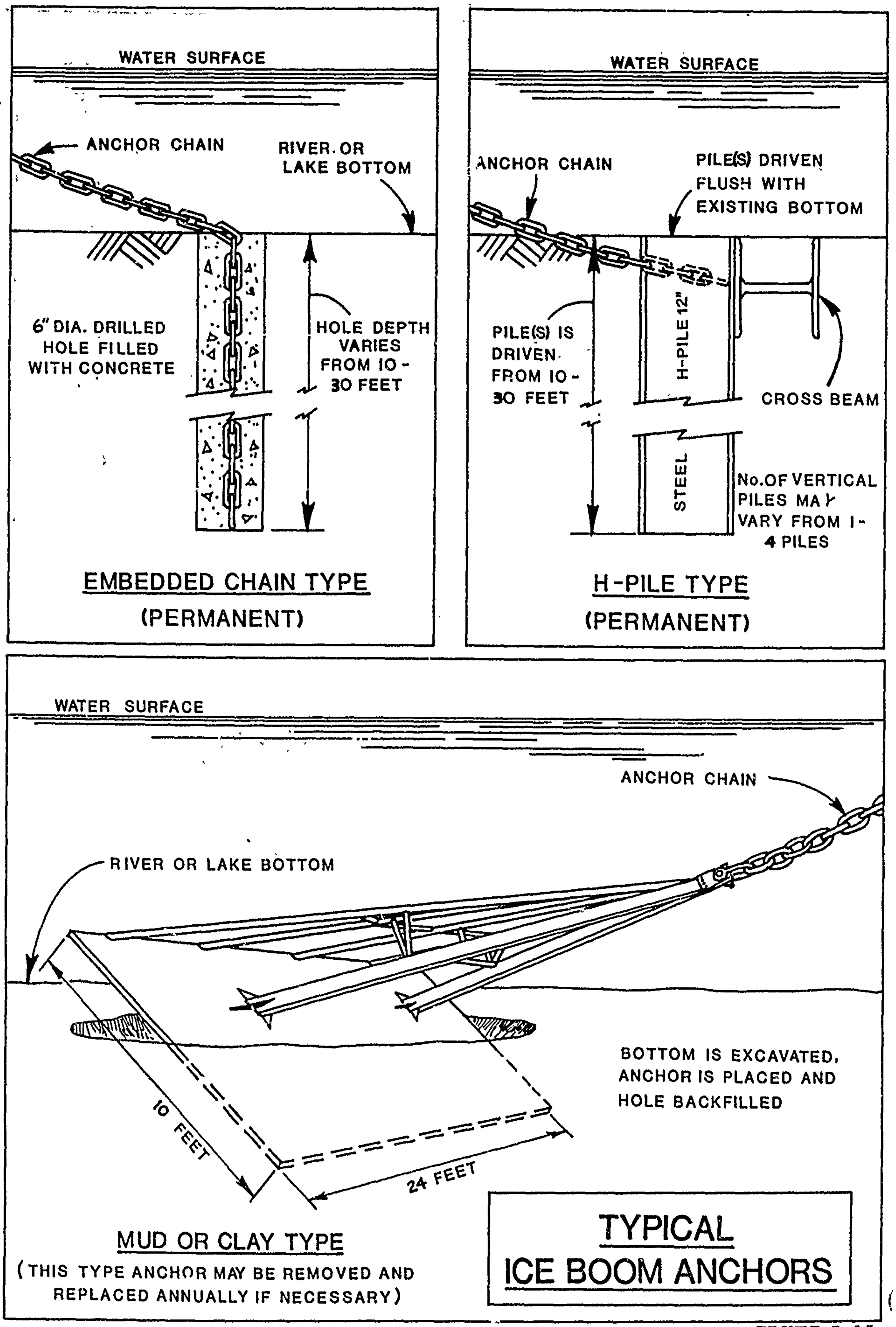

ICE COVER
MAIN BOOM FLOATS
(SIZE 1'X 2'X 20')
200 FT. TO 400 FT.
FLOW
ANCHOR FLOAT
BOOM & ANCHOR CABLES
(1" TO 3" DIA.)
100' TO 400' LONG
ANCHOR
OF ANCHOR VARIES
WITH SOIL CONDITIONS
TYPICAL RIVER ICE BOOM
FOR USE IN CONNECTING CHANNELS
(ST. MARYS, DETROIT, & ST. LAWRENCE RIVERS)

FIGURE B-14



TYPICAL ICE BOOM ANCHORS

FIGURE B-15

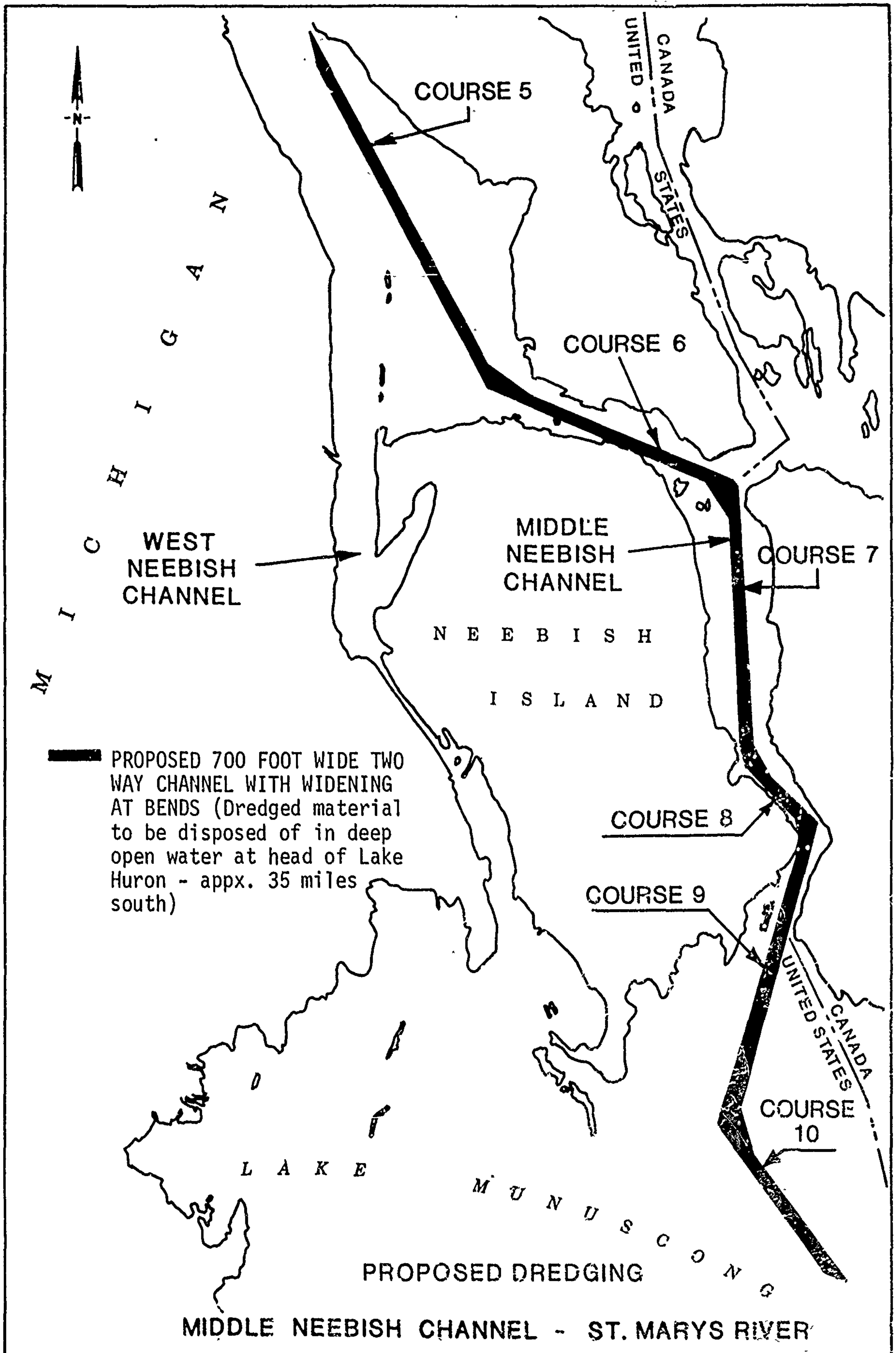
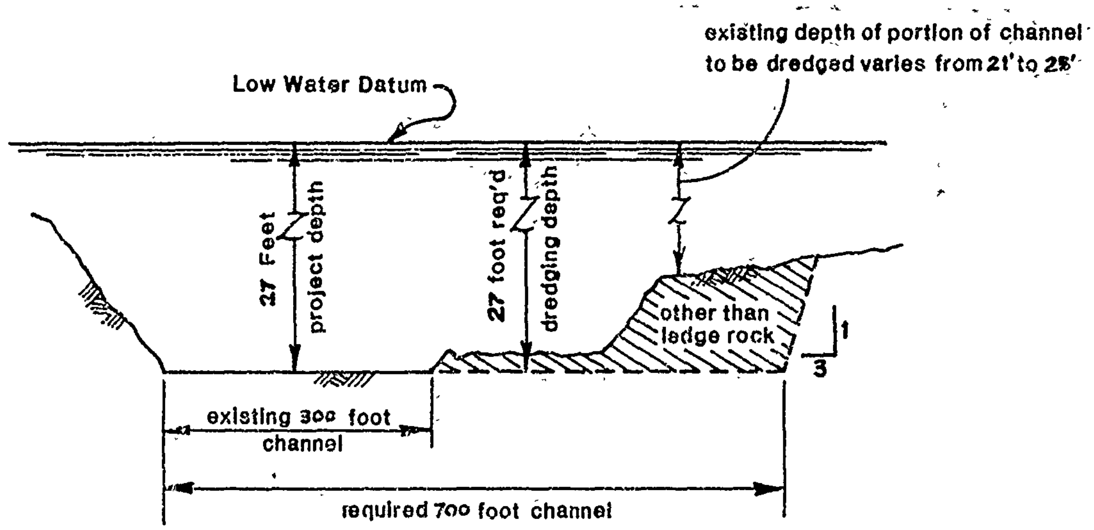
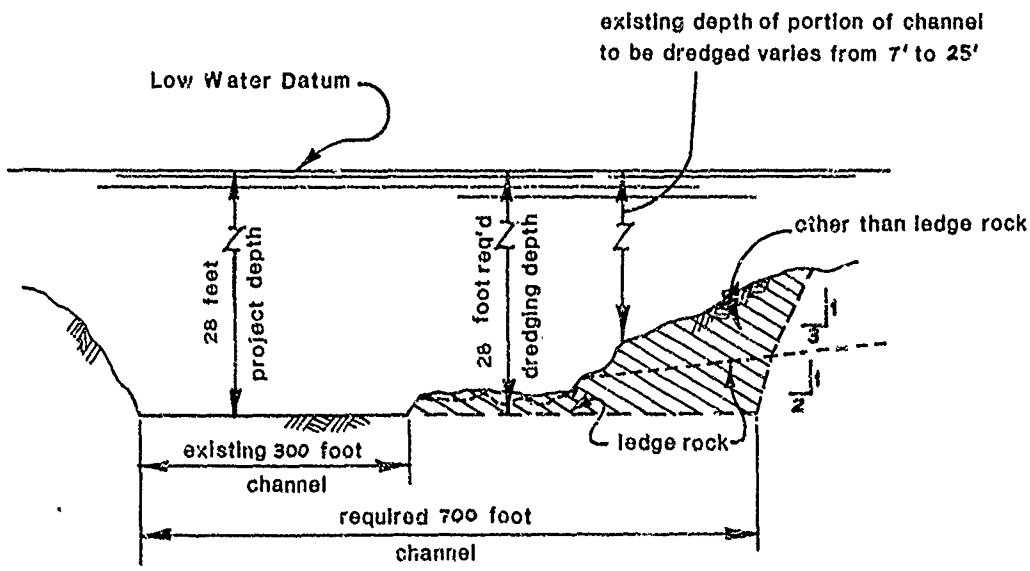

N
COURSE 5
UNITED STATES
CANADA
M I C H I G A N
COURSE 6
WEST NEEBISH CHANNEL
MIDDLE NEEBISH CHANNEL
COURSE 7
N E E B I S H
I S L A N D
PROPOSED 700 FOOT WIDE TWO WAY CHANNEL WITH WIDENING AT BENDS (Dredged material to be disposed of in deep open water at head of Lake Huron - appx. 35 miles south)
COURSE 8
COURSE 9
UNITED STATES
CANADA
COURSE 10
L A K E
M U N U S C O N G
PROPOSED DREDGING
MIDDLE NEEBISH CHANNEL - ST. MARYS RIVER

FIGURE B-16



TYPICAL SECTION WITH OVERBURDEN ONLY



TYPICAL SECTION WITH ROCK AND OVERBURDEN

TYPICAL DREDGING CROSS SECTIONS

OF MIDDLE NEEBISH CHANNEL, ST. MARYS RIVER

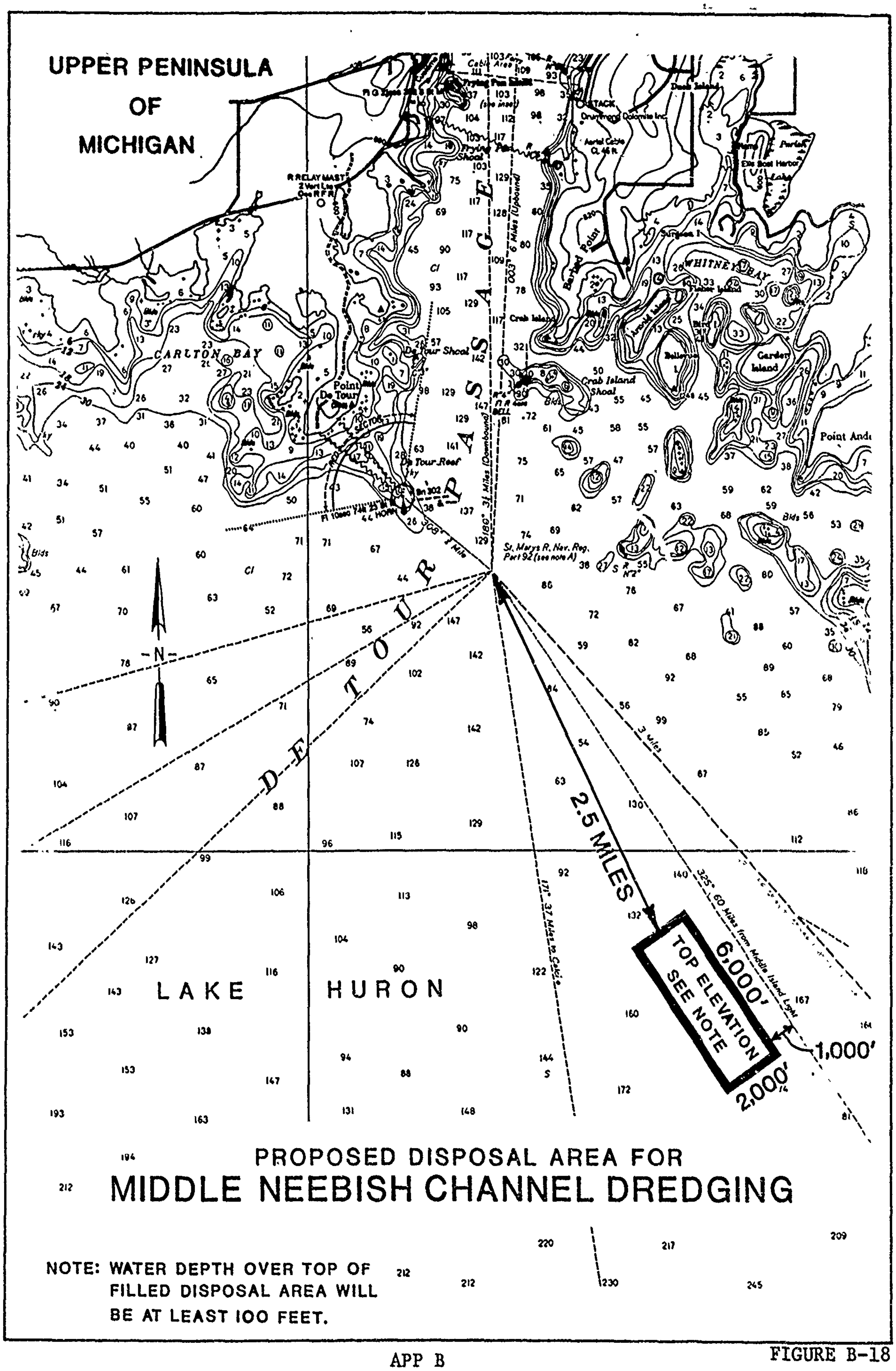
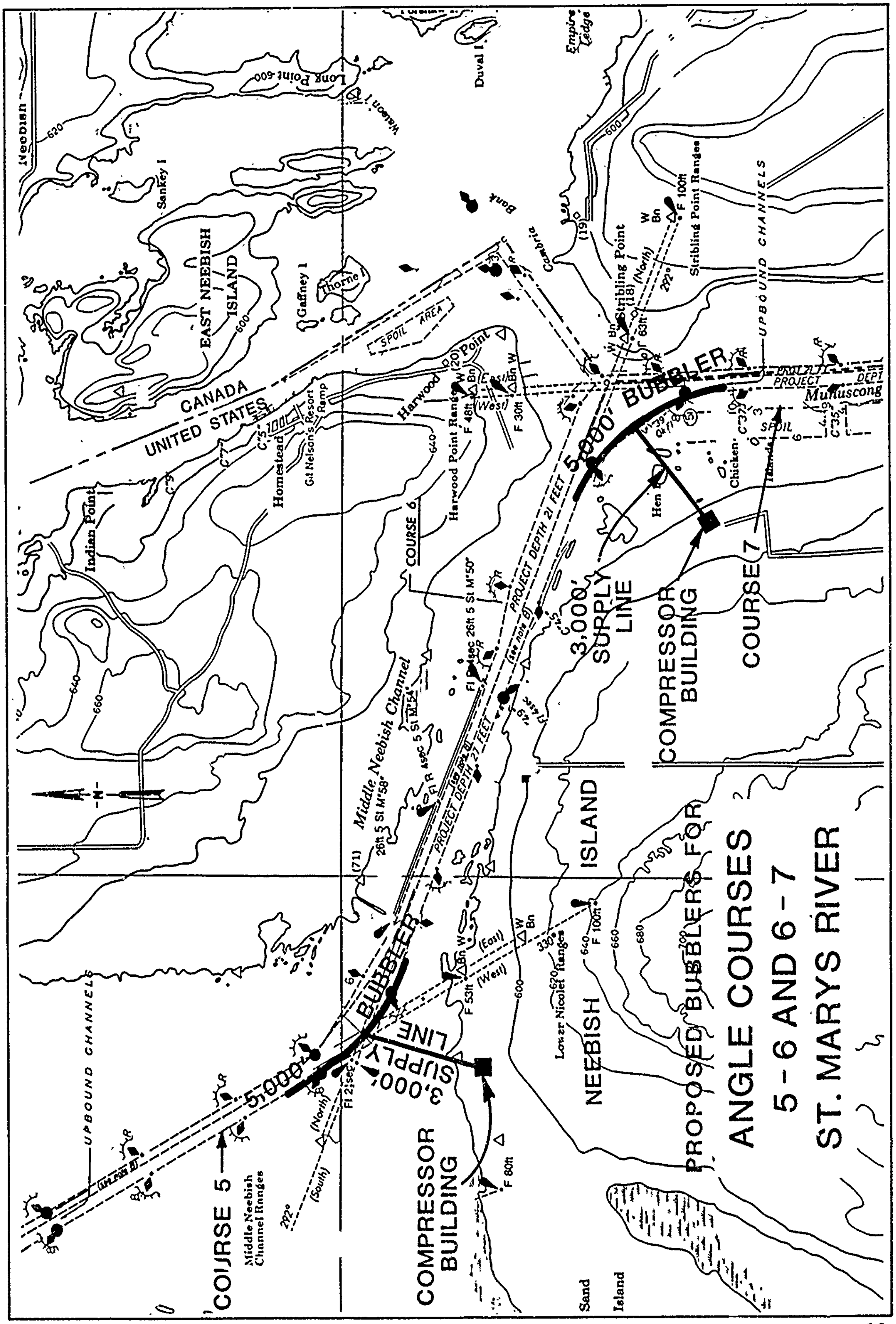
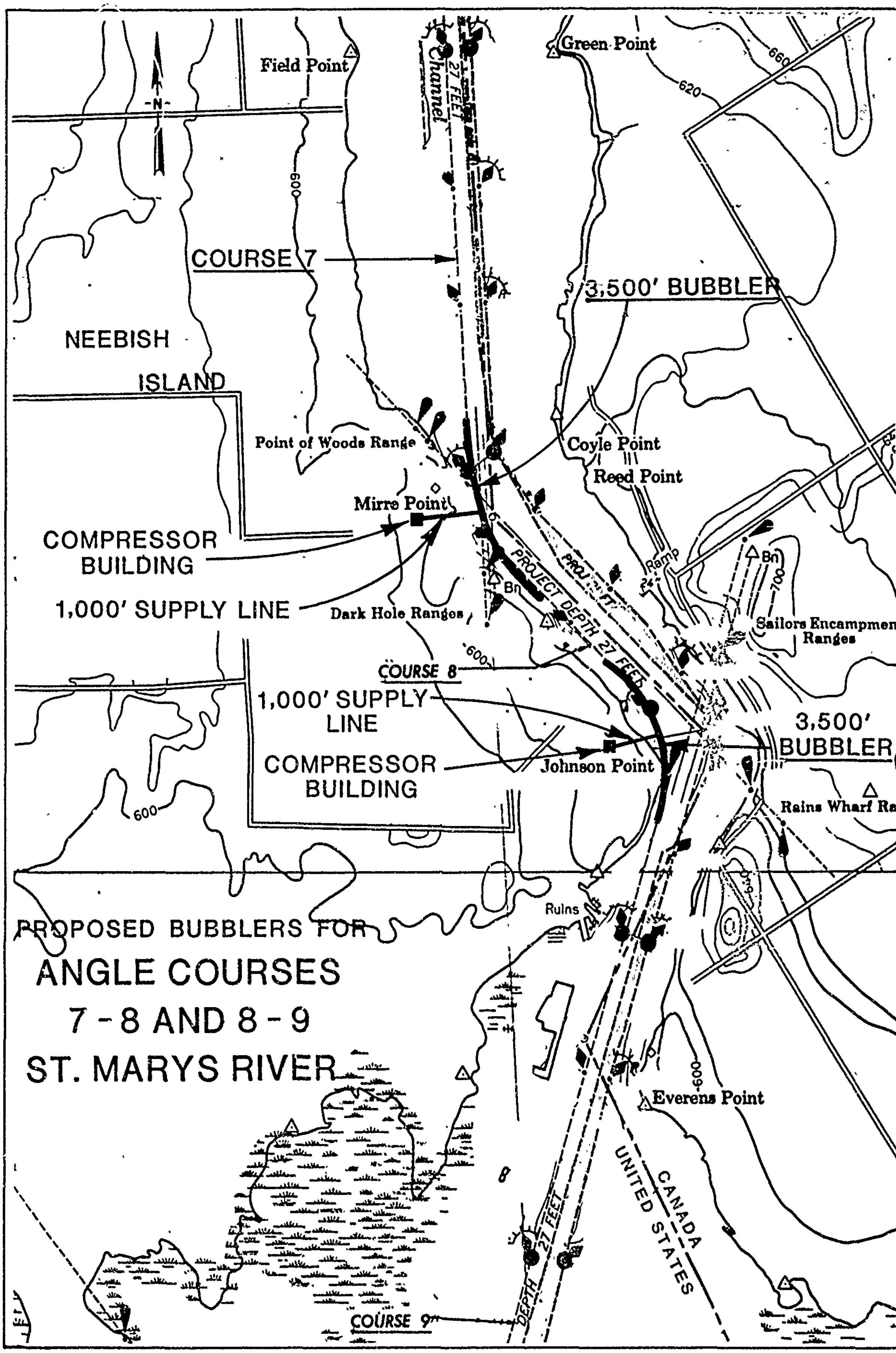

UPPER PENINSULA
OF
MICHIGAN
CARLTON BAY
Point De Tour
De Tour Shoal
De Tour Reef
Crab Island
Crab Island Shoal
WHITNEY BAY
Garden Island
Point Andé
Frying Pan Island
Drummond Dolomite Inc
Ellis Boat Harbor
Barbed Point
DE TOUR PASSAGE
St. Marys R. Nav. Reg. Part 92 (see note A)
2.5 MILES
6,000'
1,000'
2,000'
TOP ELEVATION SEE NOTE
N
LAKE
HURON
PROPOSED DISPOSAL AREA FOR
MIDDLE NEEBISH CHANNEL DREDGING
NOTE: WATER DEPTH OVER TOP OF FILLED DISPOSAL AREA WILL BE AT LEAST 100 FEET.

FIGURE B-18



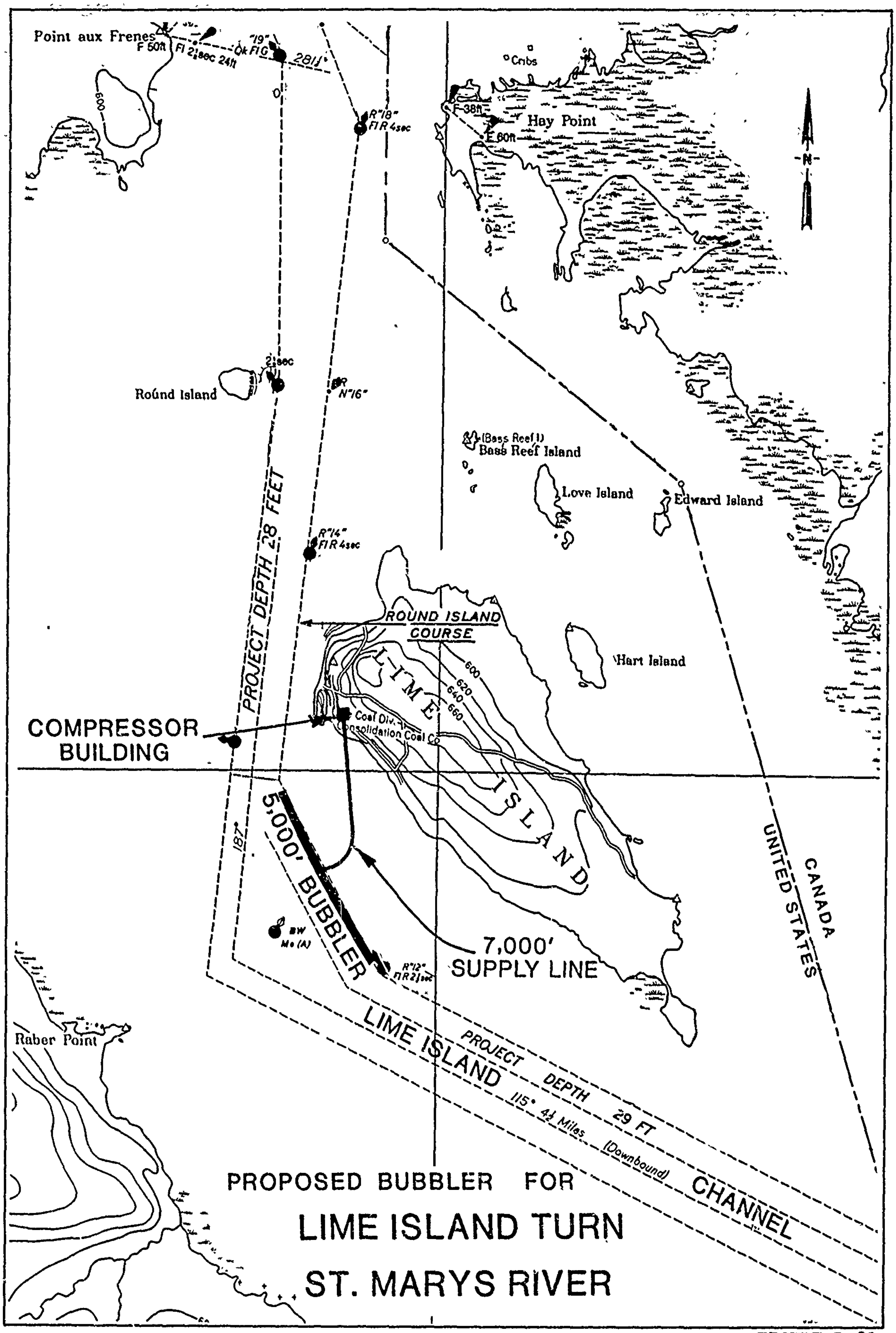
APP B

FIGURE B-19



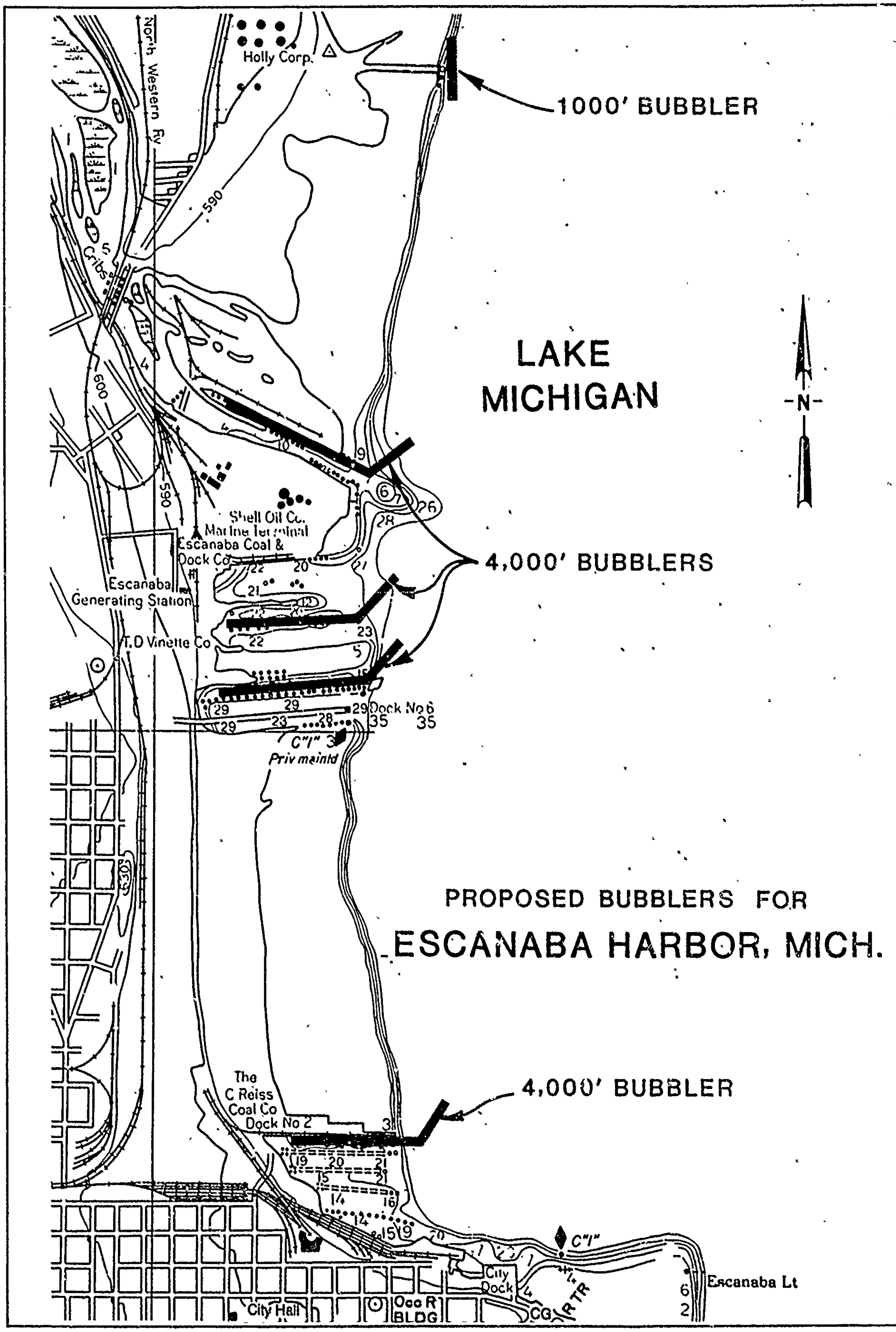
Field Point
Green Point
27 FEET Channel
620
660
N
609
COURSE 7
3,500' BUBBLER
NEEBISH
ISLAND
Point of Woods Range
Coyle Point
Reed Point
Mirre Point
COMPRESSOR
BUILDING
1,000' SUPPLY LINE
Dark Hole Ranges
PROJECT DEPTH 27 FEET
Ramp
Bn
Sailors Encampmen
Ranges
600
COURSE 8
1,000' SUPPLY
LINE
3,500'
BUBBLER
COMPRESSOR
BUILDING
Johnson Point
Rains Wharf Ra
600
Ruins
PROPOSED BUBBLERS FOR
ANGLE COURSES
7-8 AND 8-9
ST. MARYS RIVER
Everens Point
CANADA
UNITED STATES
DEPTH 27 FEET
COURSE 9

FIGURE B-20



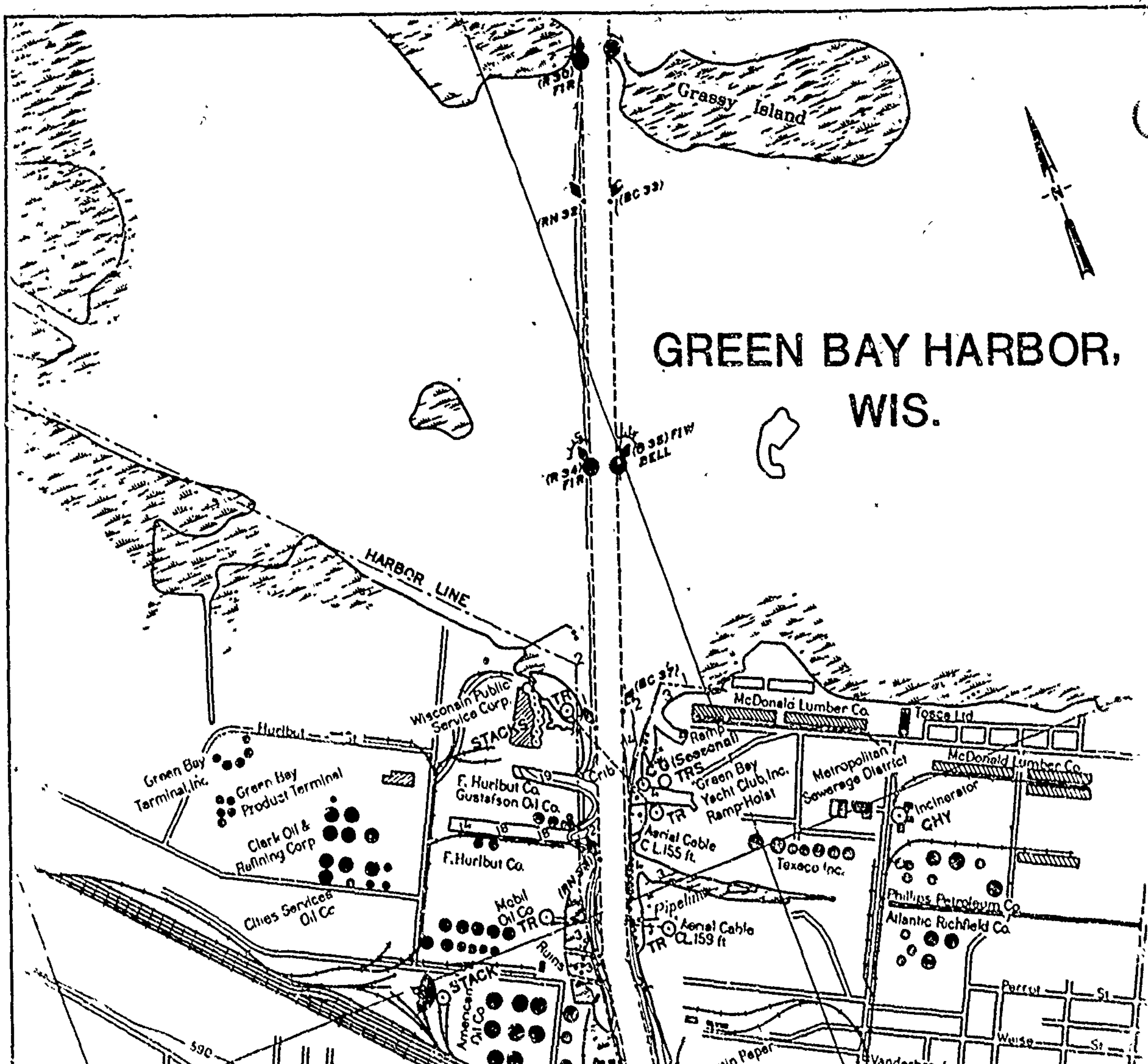
APP B

FIGURE B-21



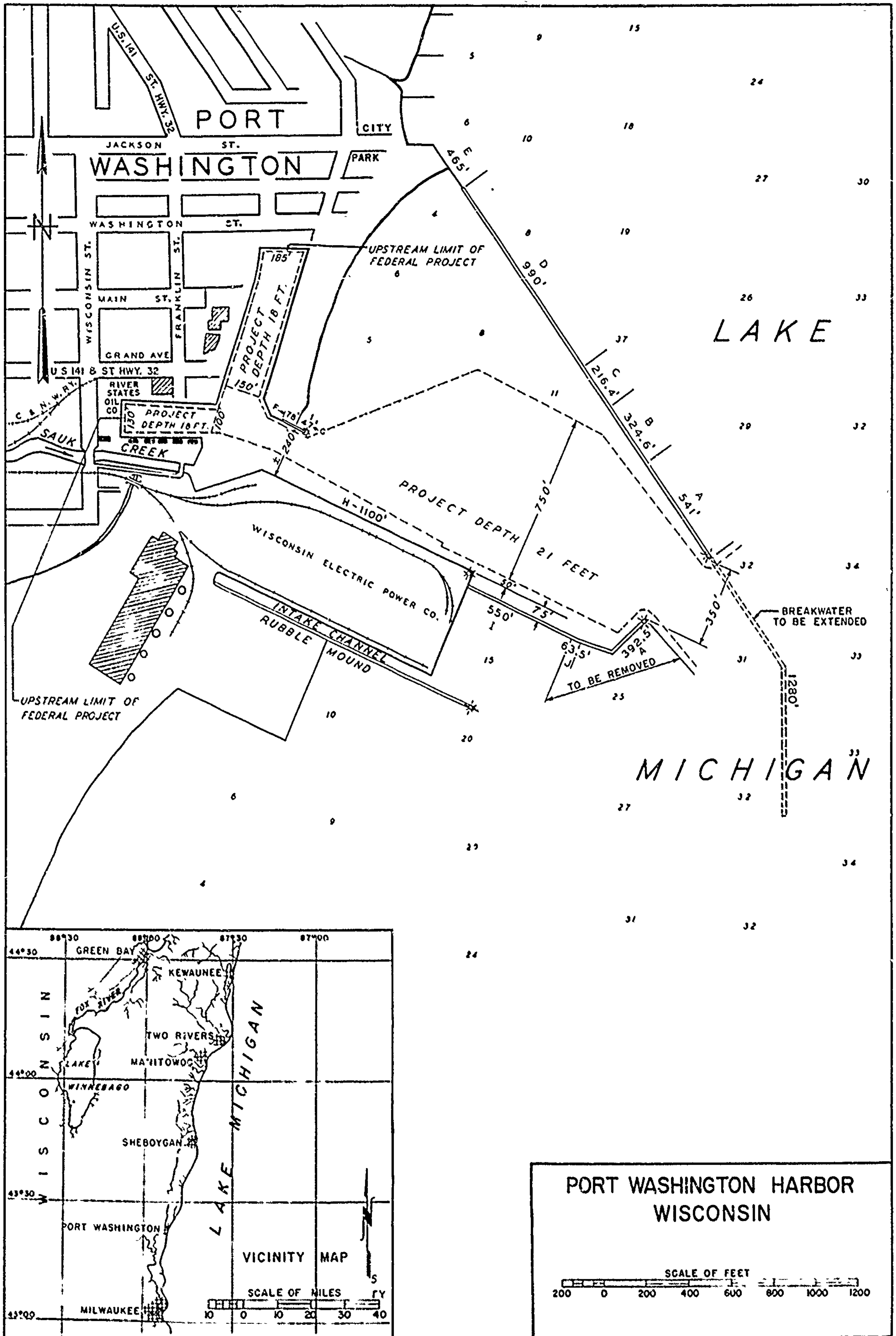
APP B

FIGURE B-22



APP B

FIGURE B-23



PORT
WASHINGTON
JACKSON ST.
WASHINGTON ST.
MAIN ST.
GRAND AVE
WISCONSIN ST.
FRANKLIN ST.
U.S. 141
ST. HWY. 32
U S 141 & ST HWY. 32
CITY
PARK
RIVER STATES OIL CO.
C. & N. W. RY.
SAUK CREEK
UPSTREAM LIMIT OF FEDERAL PROJECT
PROJECT DEPTH 18 FT.
PROJECT DEPTH 21 FEET
WISCONSIN ELECTRIC POWER CO.
INTAKE CHANNEL
RUBBLE MOUND
TO BE REMOVED
BREAKWATER TO BE EXTENDED
LAKE
MICHIGAN
PORT WASHINGTON HARBOR
WISCONSIN
SCALE OF FEET
VICINITY MAP
SCALE OF MILES
GREEN BAY
KEWAUNEE
TWO RIVERS
MANITOWOC
SHEBOYGAN
PORT WASHINGTON
MILWAUKEE
LAKE WINNEBAGO
FOX RIVER
WISCONSIN
LAKE MICHIGAN

FIGURE B-24

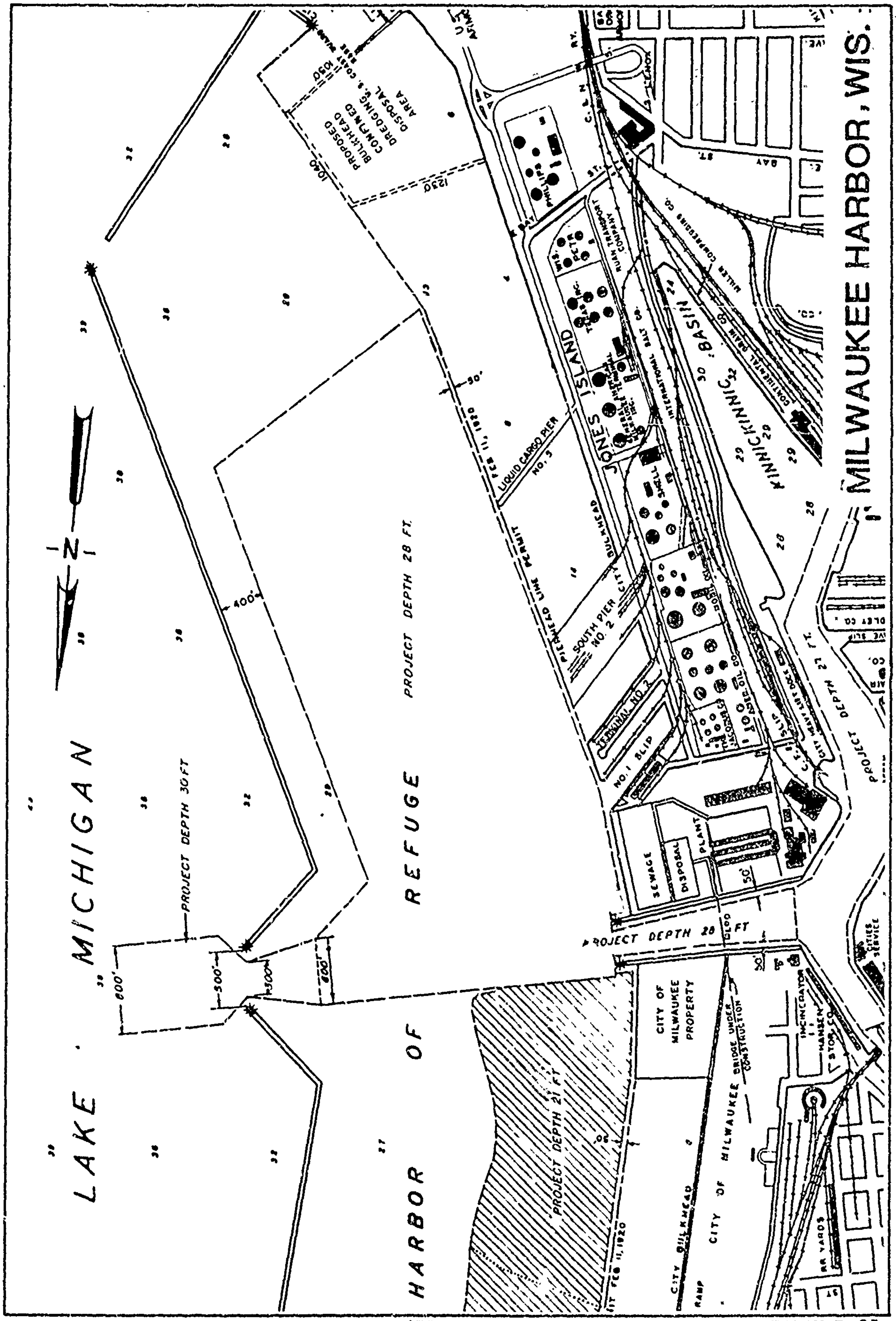
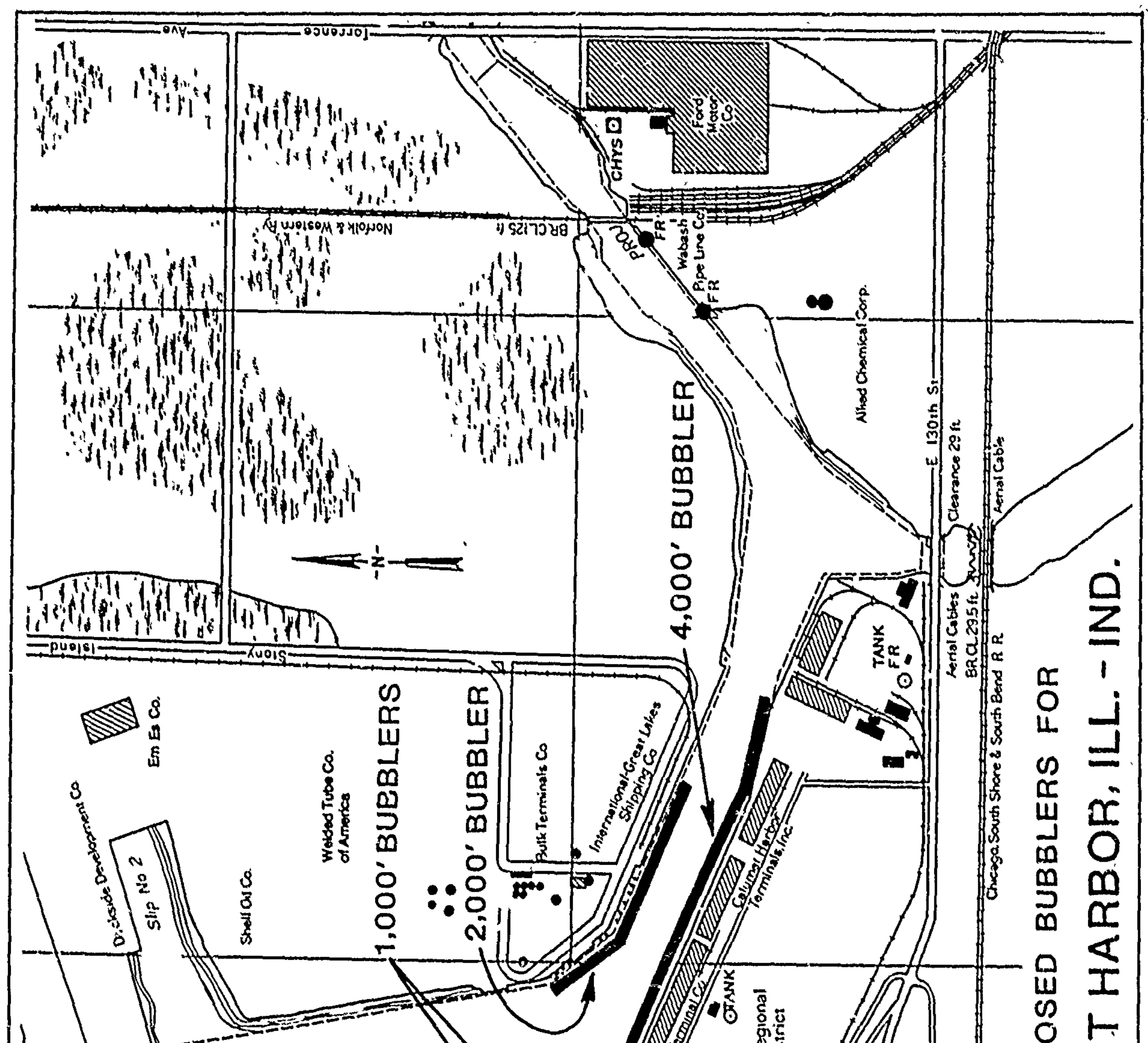
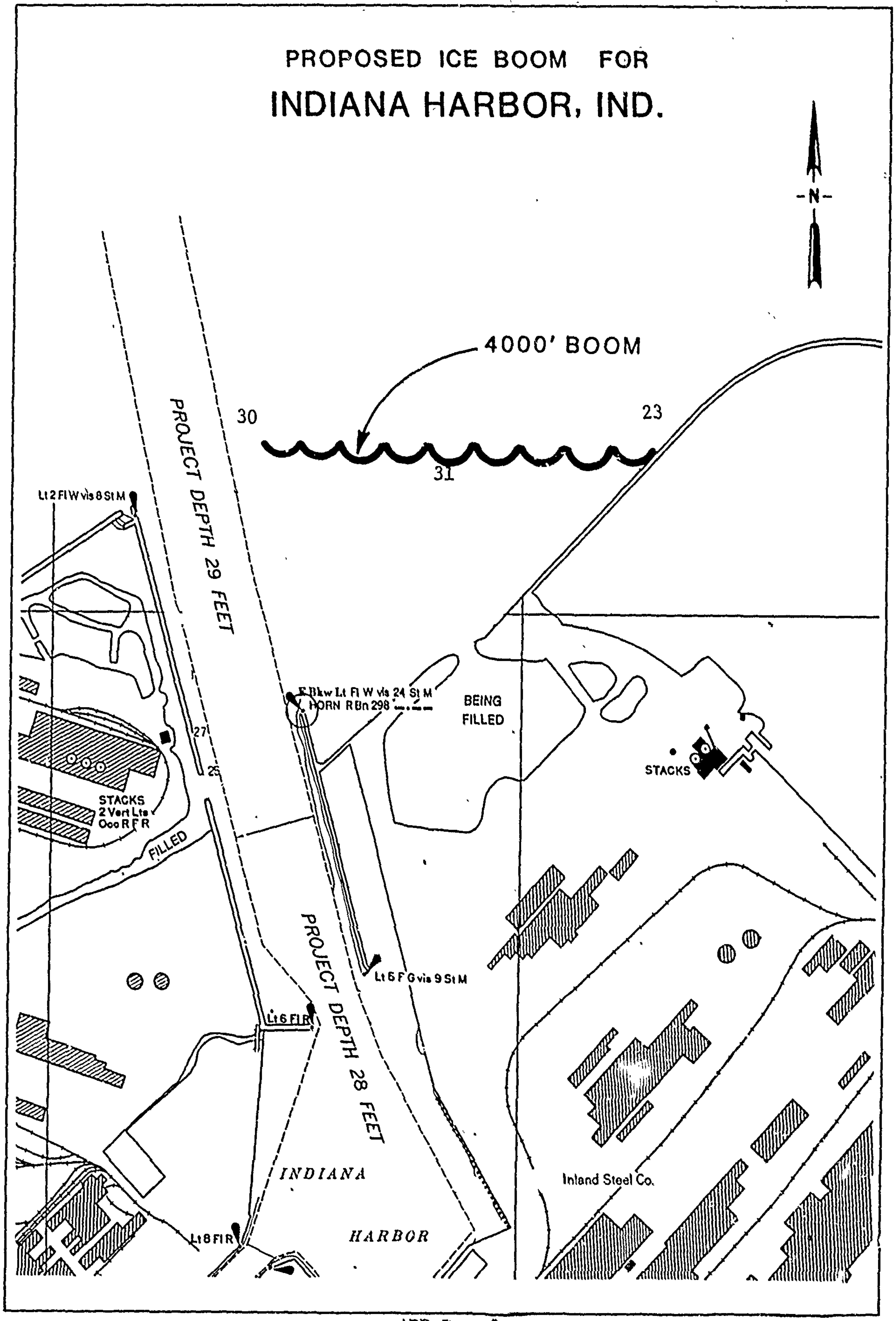

MILWAUKEE HARBOR, WIS.
LAKE MICHIGAN
HARBOR OF REFUGE
N
PROJECT DEPTH 30 FT
PROJECT DEPTH 28 FT.
PROJECT DEPTH 28 FT
PROJECT DEPTH 27 FT.
PROJECT DEPTH 21 FT
PROPOSED BULKHEAD CONFINED DREDGING DISPOSAL AREA
JONES ISLAND
KINNICKINNIC BASIN
SOUTH PIER NO. 2
LIQUID CARGO PIER NO. 3
PIERHEAD LINE PERMIT FEB 11, 1920
CITY BULKHEAD
TERMINAL NO. 2
NO. 1 SLIP
SEWAGE DISPOSAL PLANT
CITY OF MILWAUKEE PROPERTY
CITY OF MILWAUKEE BRIDGE UNDER CONSTRUCTION
CITY BULKHEAD
INTERNATIONAL SALT CO.
CONTINENTAL GRAIN CO.
PHILLIPS
SHELL
400'
800'
500'
50'

FIGURE B-25



APP B

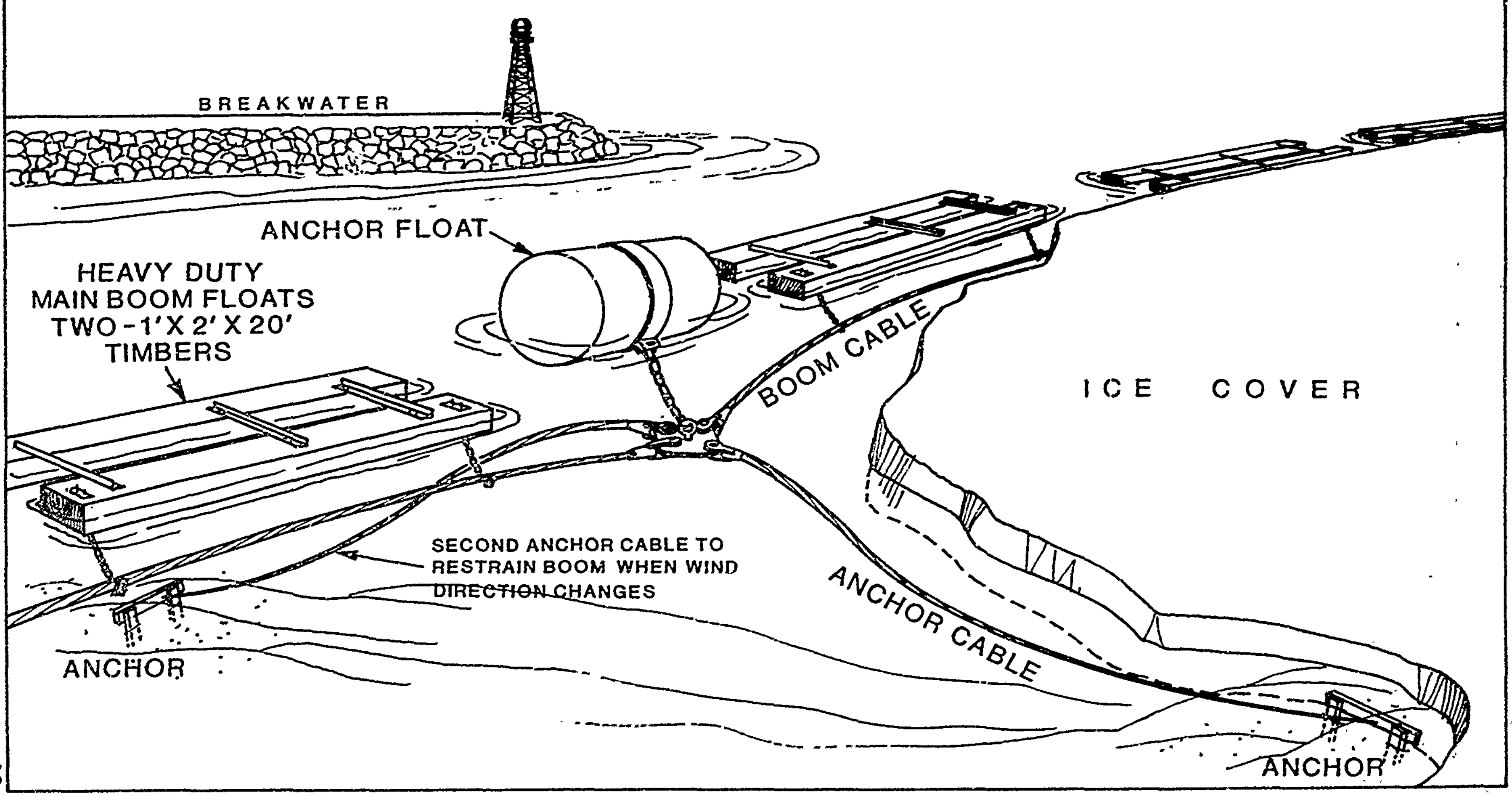
FIGURE B-26



APP B

FIGURE B-27

TYPICAL HARBOR OR OPEN LAKE ICE BOOM



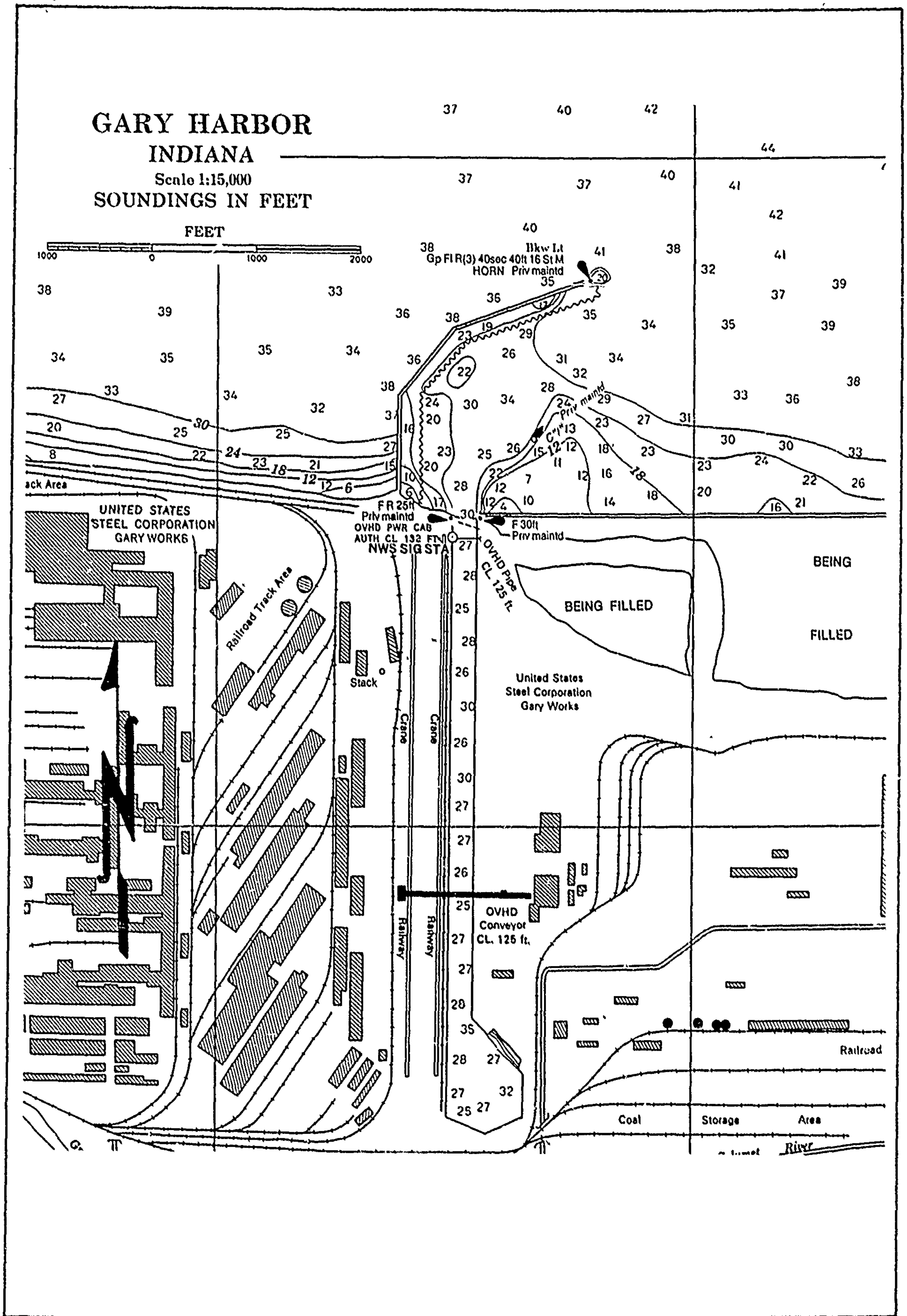
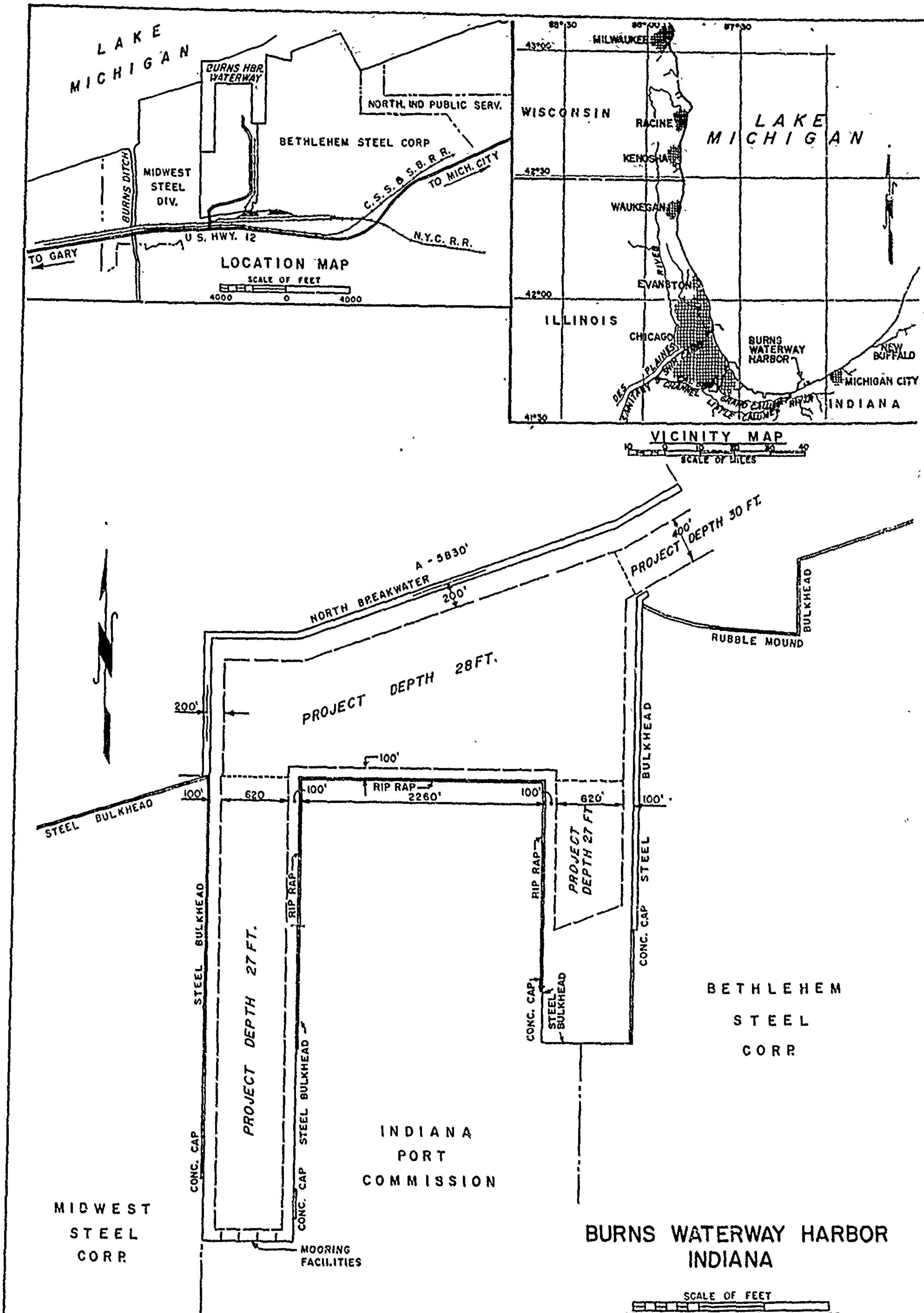

GARY HARBOR
INDIANA
Scale 1:15,000
SOUNDINGS IN FEET
FEET
1000 0 1000 2000
Bkw Lt
Gp Fl R(3) 40sec 40ft 16 St M
HORN Priv maintd
Priv maintd
F R 25ft
Priv maintd
OVHD PWR CAB
AUTH CL 132 FT
NWS SIG STA
F 30ft
Priv maintd
OVHD Pipe
CL. 125 ft.
UNITED STATES
STEEL CORPORATION
GARY WORKS
Railroad Track Area
BEING FILLED
BEING
FILLED
United States
Steel Corporation
Gary Works
Stack
Crane
Crane
Railway
Railway
OVHD
Conveyor
CL. 125 ft.
Railroad
Coal
Storage
Area
River

FIGURE B-29



LAKE MICHIGAN
BURNS HBR. WATERWAY
NORTH. IND PUBLIC SERV.
BETHLEHEM STEEL CORP
MIDWEST STEEL DIV.
BURNS DITCH
C.S.S. & S.B.R.R.
TO MICH. CITY
U.S. HWY. 12
N.Y.C. R.R.
TO GARY
LOCATION MAP
SCALE OF FEET
4000 0 4000
MILWAUKEE
WISCONSIN
RACINE
KENOSHA
WAUKEGAN
LAKE MICHIGAN
EVANSTON
ILLINOIS
CHICAGO
BURNS WATERWAY HARBOR
NEW BUFFALO
MICHIGAN CITY
INDIANA
VICINITY MAP
SCALE OF MILES
NORTH BREAKWATER
A - 5830'
200'
400'
PROJECT DEPTH 30 FT.
PROJECT DEPTH 28 FT.
RUBBLE MOUND
BULKHEAD
100'
RIP RAP
2260'
620
620'
STEEL BULKHEAD
PROJECT DEPTH 27 FT.
CONC. CAP
MOORING FACILITIES
BETHLEHEM STEEL CORP.
INDIANA PORT COMMISSION
MIDWEST STEEL CORP.
BURNS WATERWAY HARBOR
INDIANA
SCALE OF FEET
600 0 600 1200

FIGURE B-3

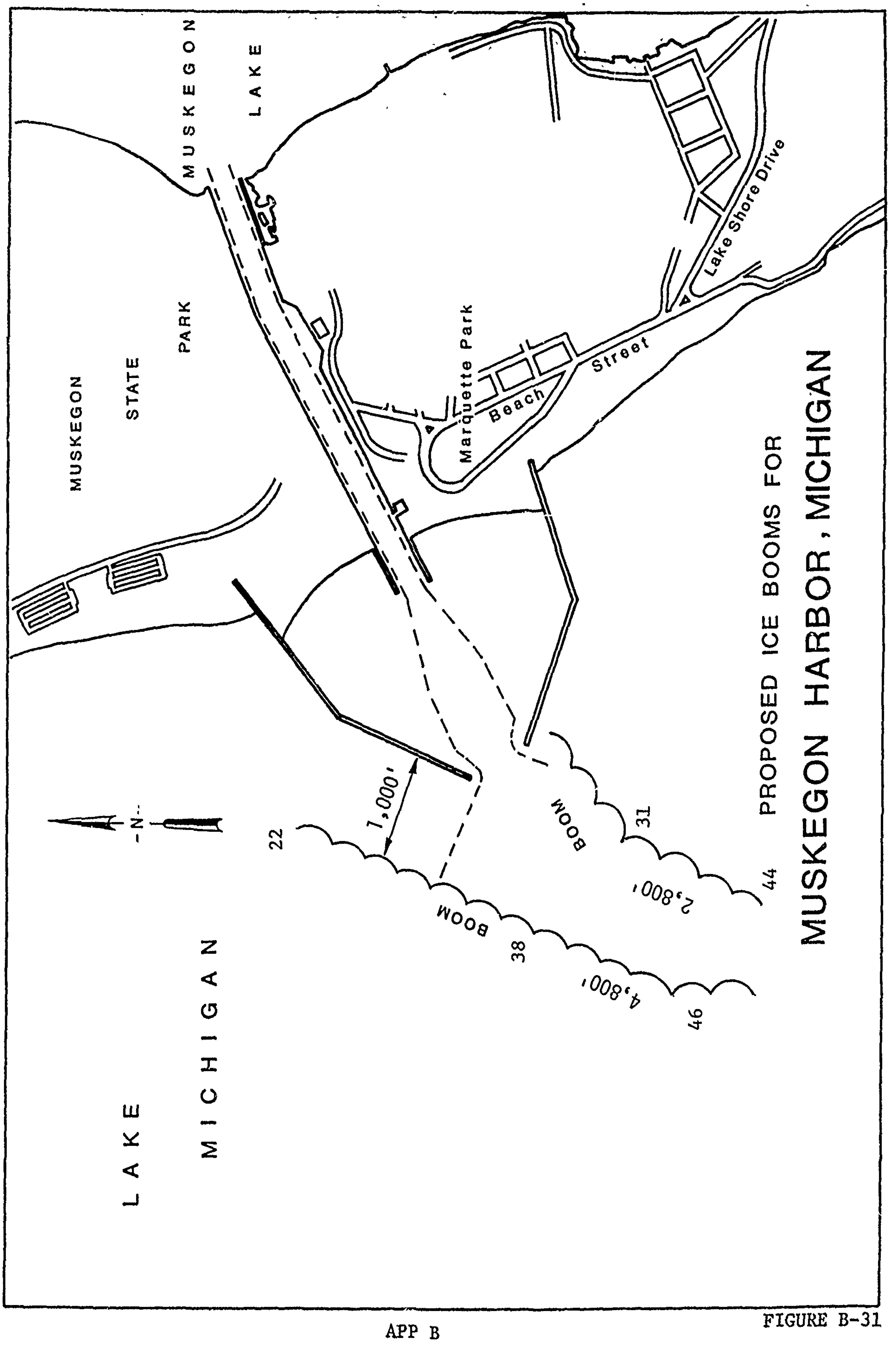
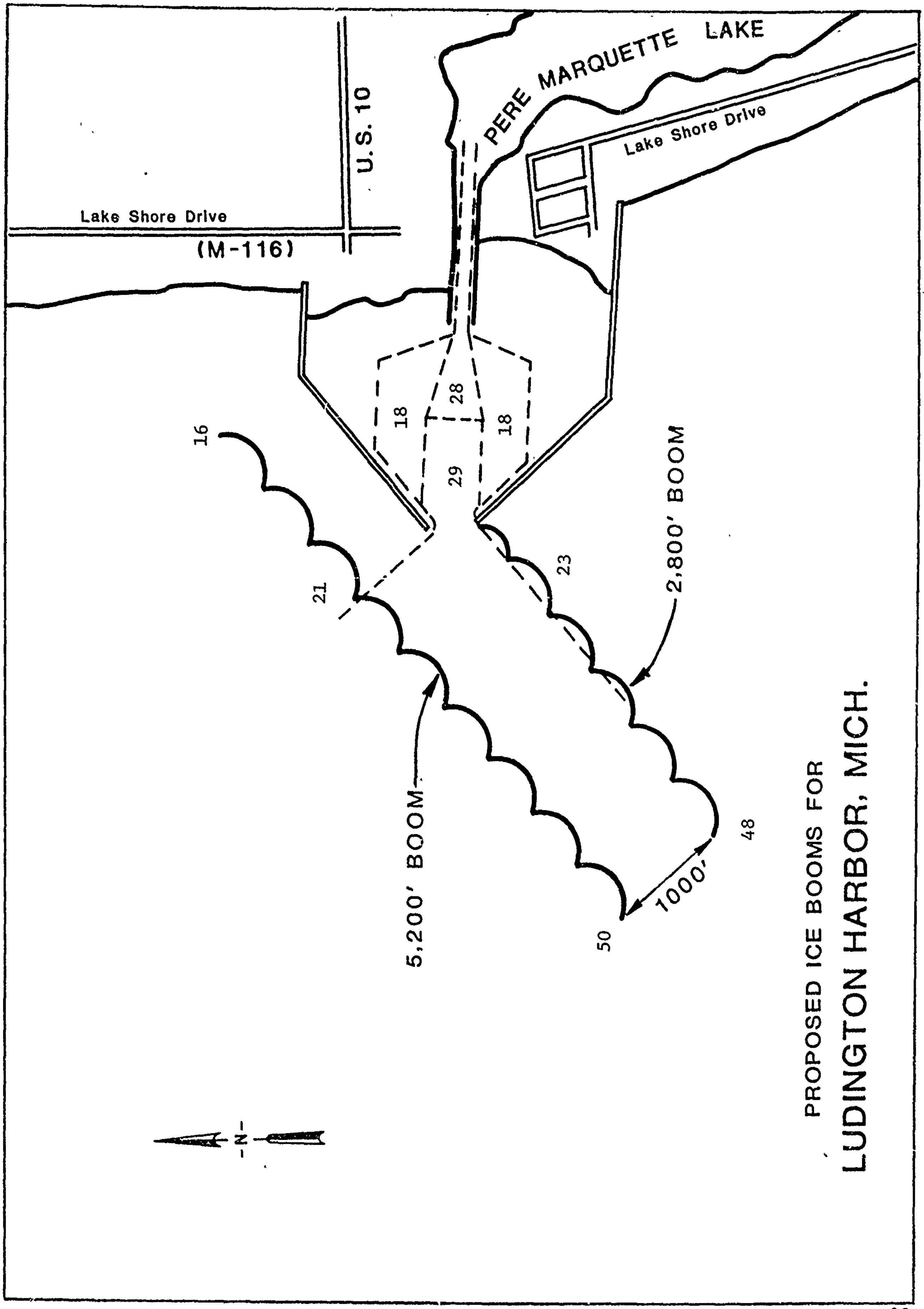
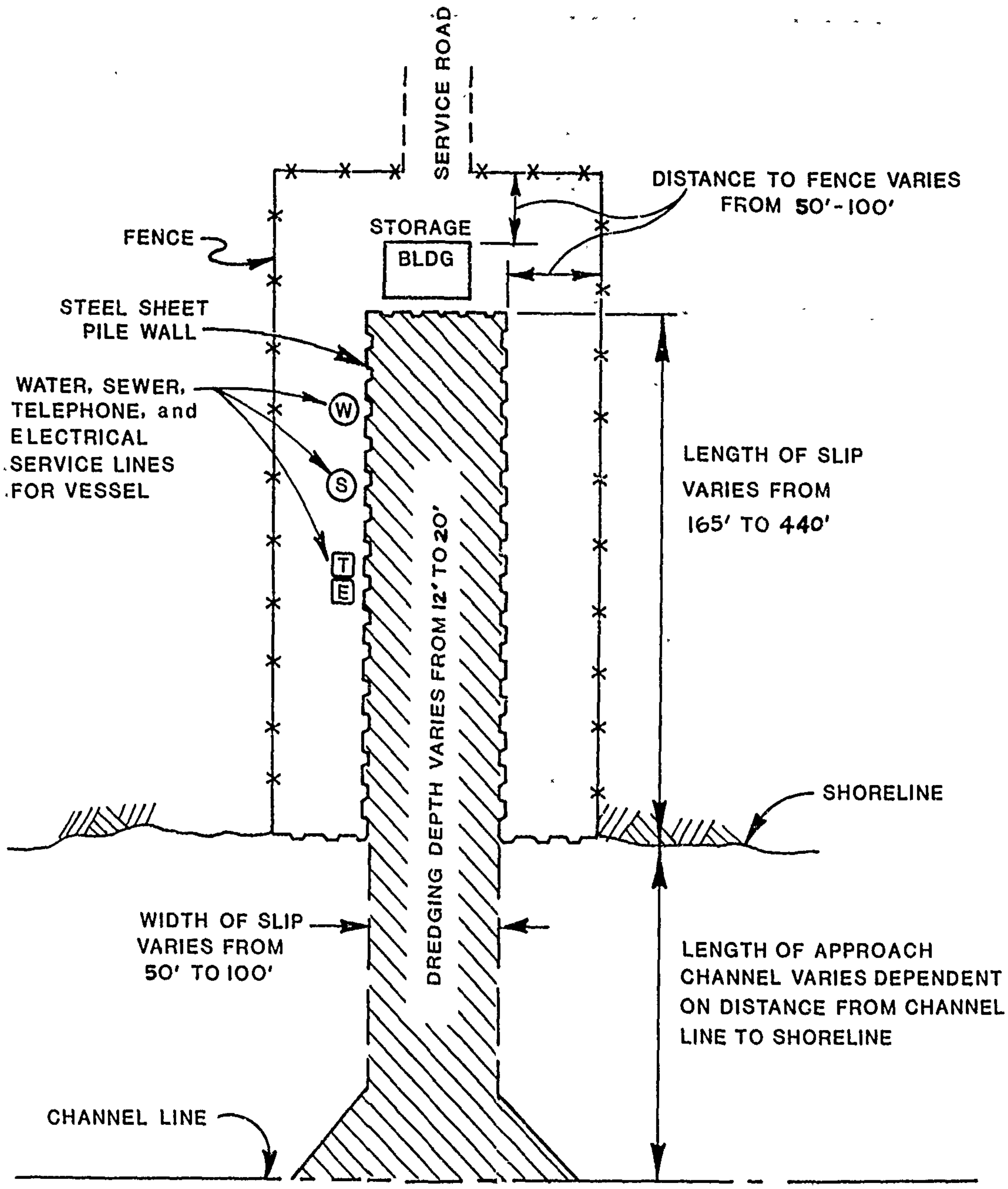

PROPOSED ICE BOOMS FOR
MUSKEGON HARBOR, MICHIGAN
MUSKEGON LAKE
MUSKEGON STATE PARK
LAKE MICHIGAN
Marquette Park
Beach
Street
Lake Shore Drive
-N-
1,000'
BOOM
2,800'
BOOM
4,800'
22
31
38
44
46

FIGURE B-31

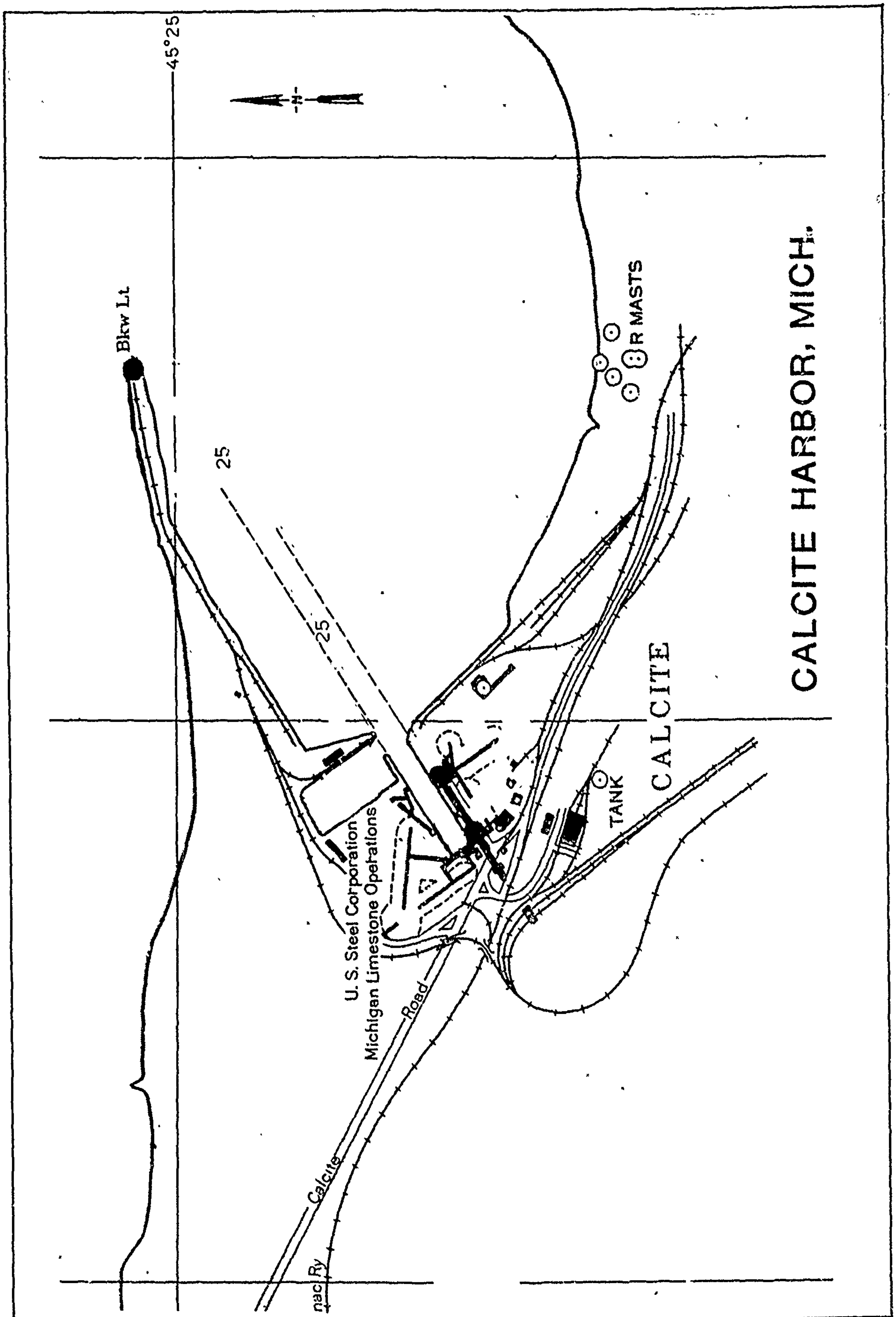


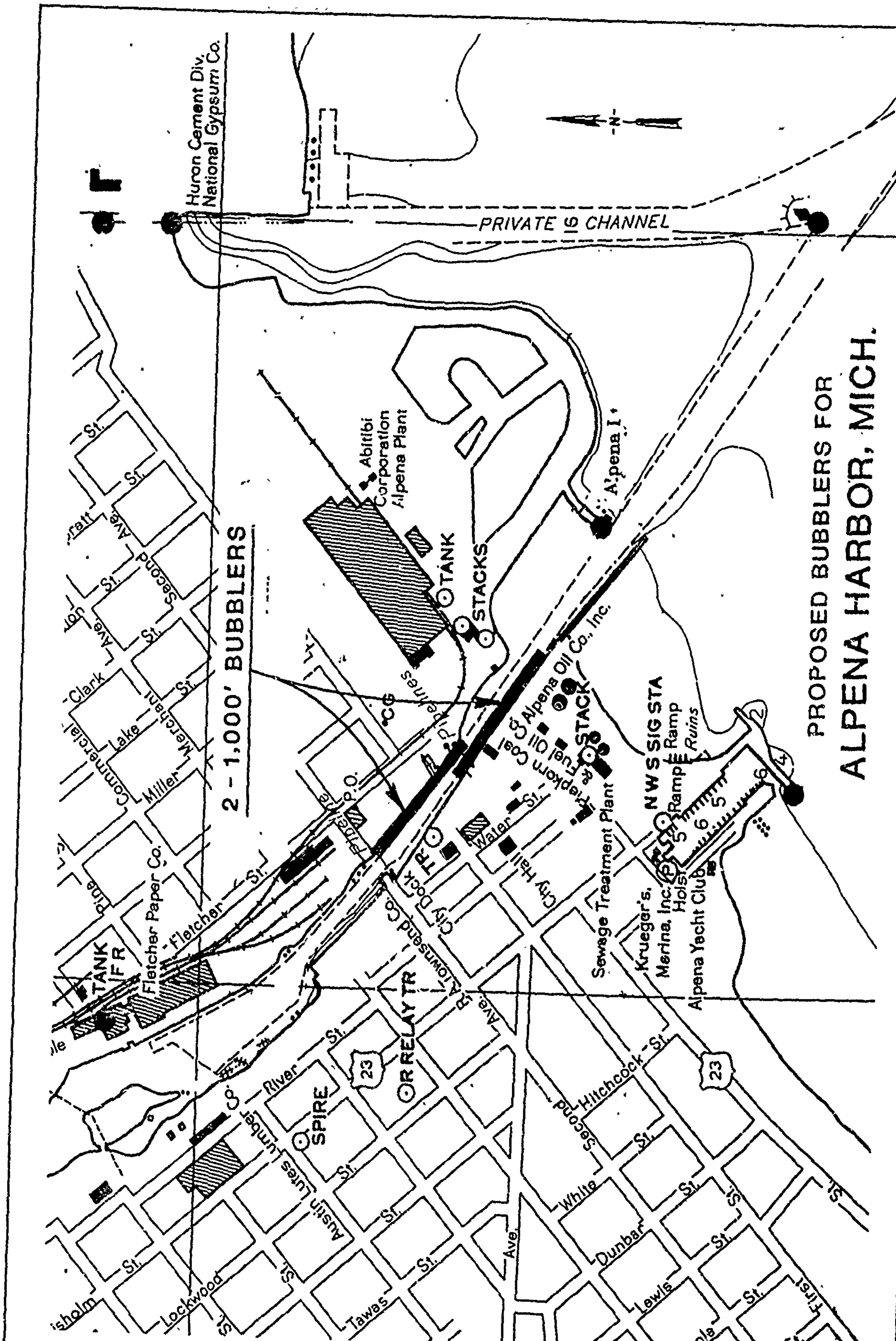
PROPOSED ICE BOOMS FOR
LUDINGTON HARBOR, MICH.



GENERALIZED

ICEBREAKER MOORING FACILITY


CALCITE HARBOR, MICH.
45°25
N
Bkw Lt
25
25
R MASTS
CALCITE
TANK
U. S. Steel Corporation
Michigan Limestone Operations
Road
Calcite
nac Ry



APP B

FIGURE B-35

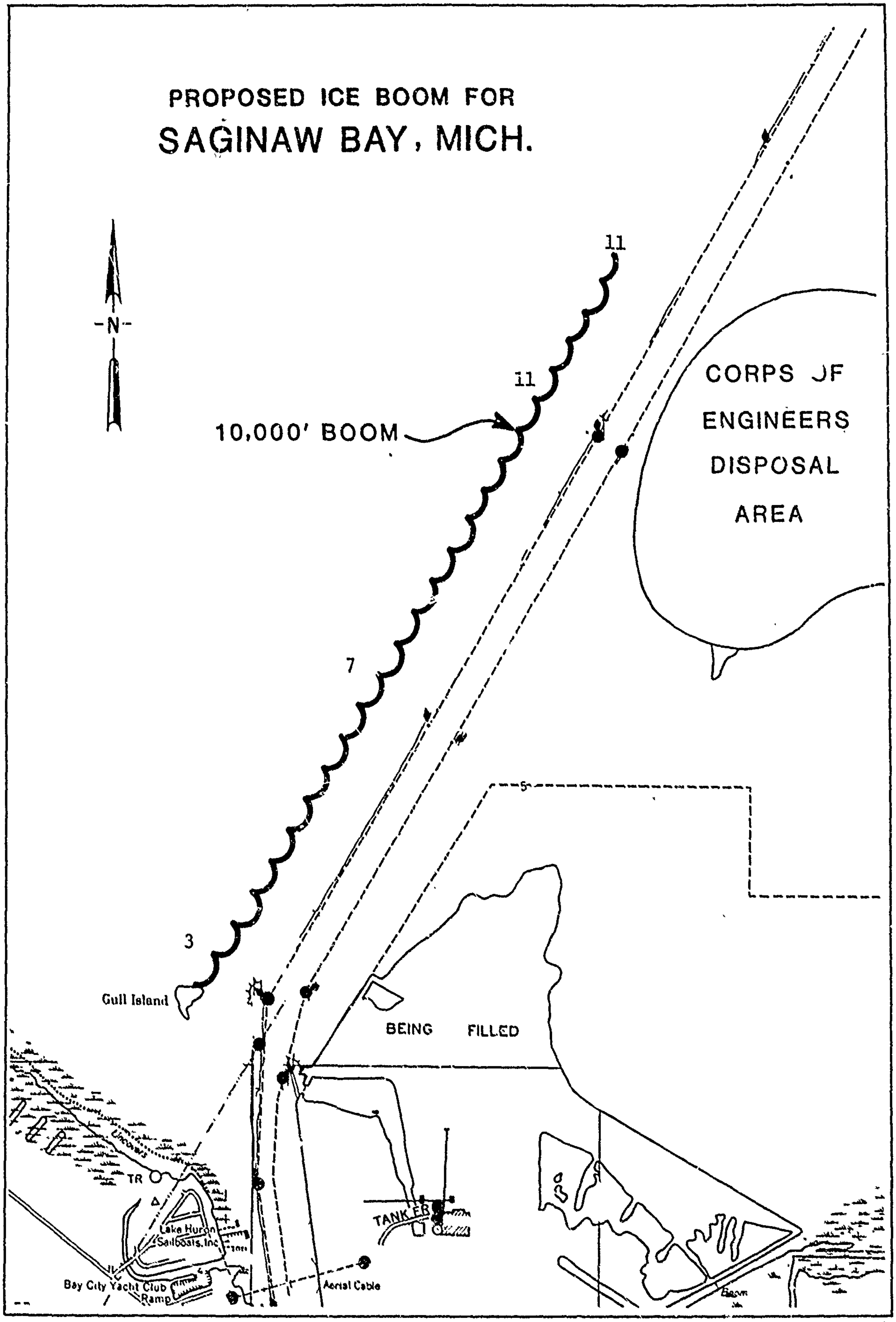
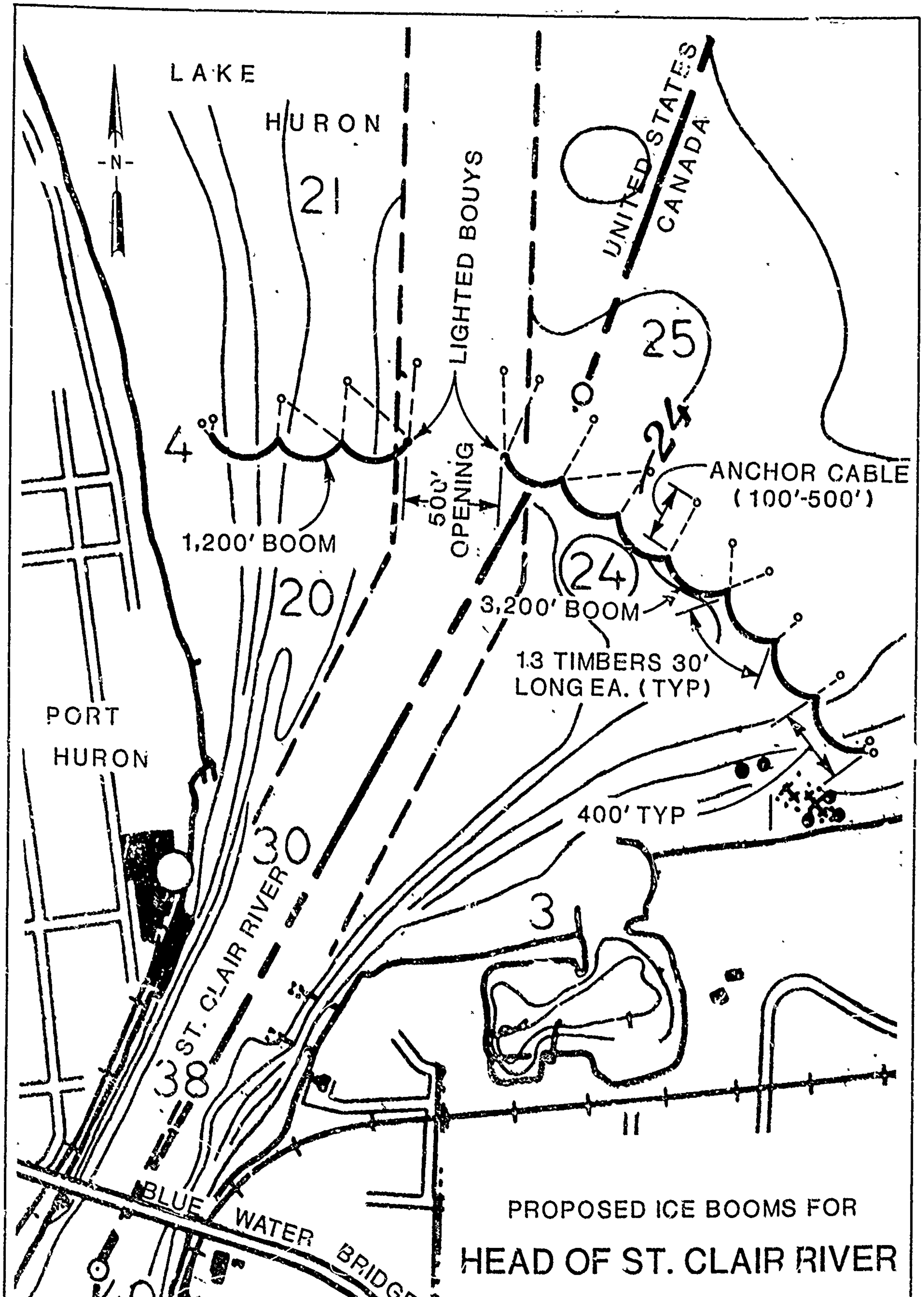
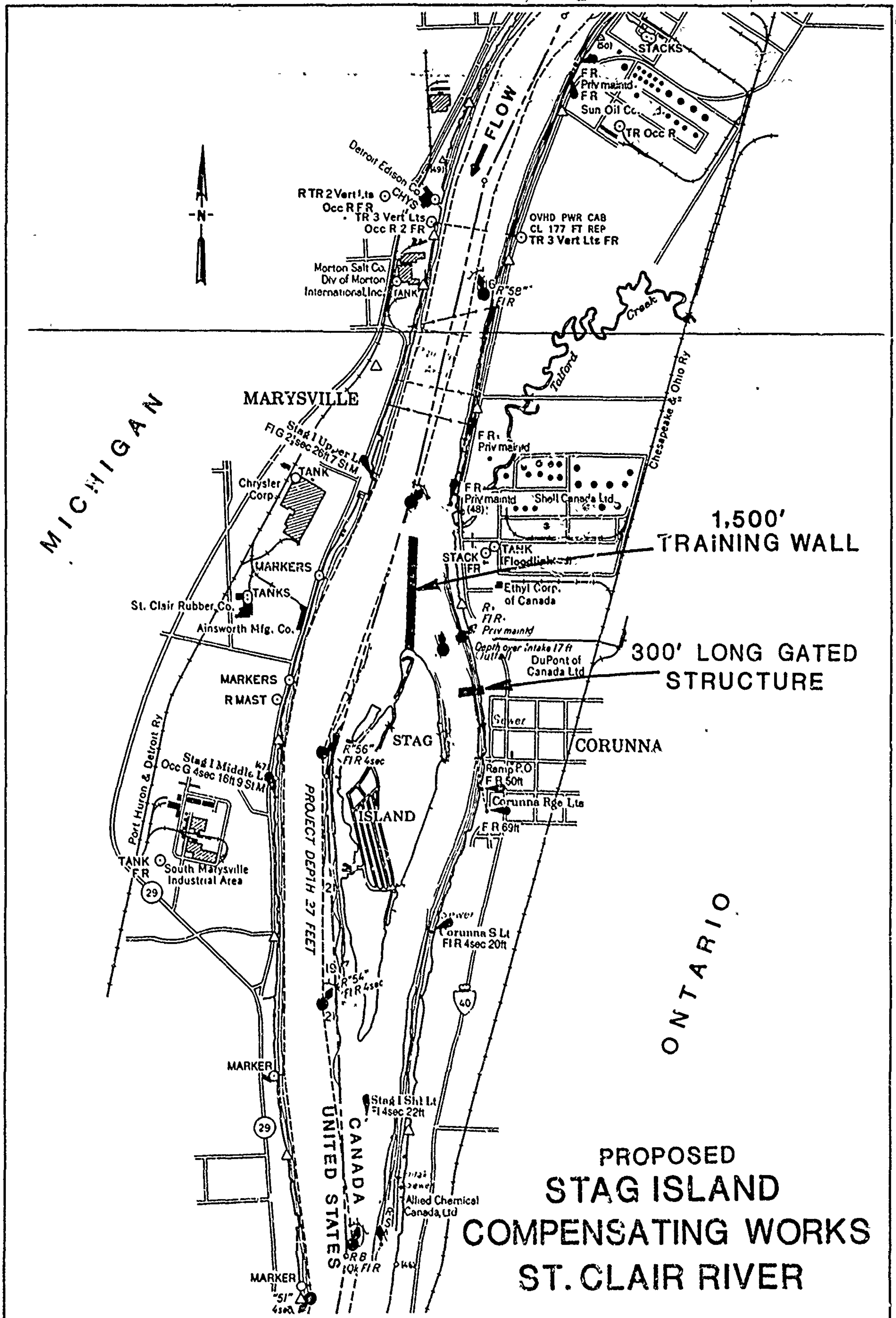

PROPOSED ICE BOOM FOR
SAGINAW BAY, MICH.
N
11
11
10,000' BOOM
7
3
CORPS OF ENGINEERS DISPOSAL AREA
Gull Island
BEING FILLED
TR
Lake Huron Sailboats, Inc
Bay City Yacht Club Ramp
Aerial Cable
TANK FR

FIGURE B-36



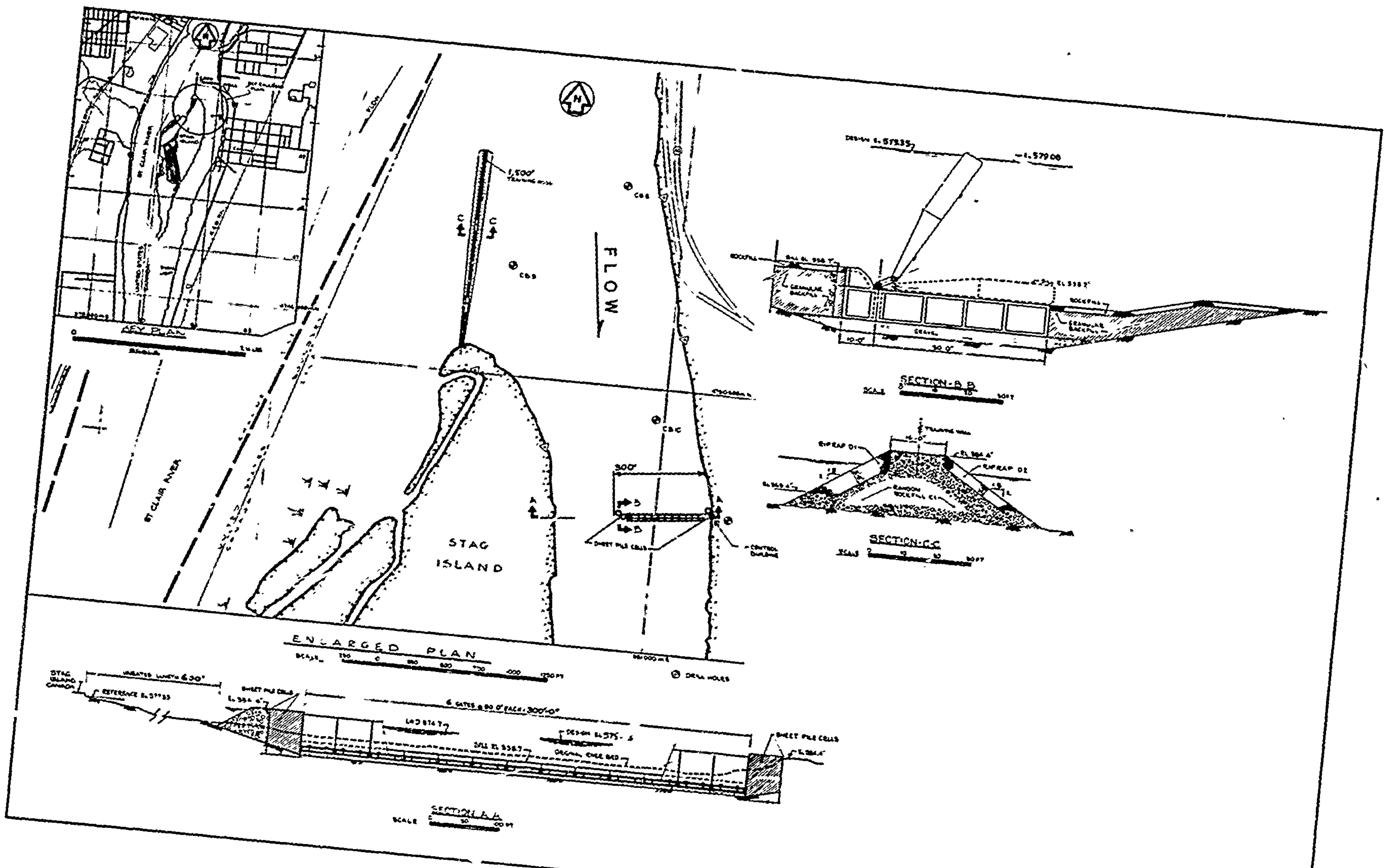
PROPOSED ICE BOOMS FOR
HEAD OF ST. CLAIR RIVER

FIGURE B-37



APP B

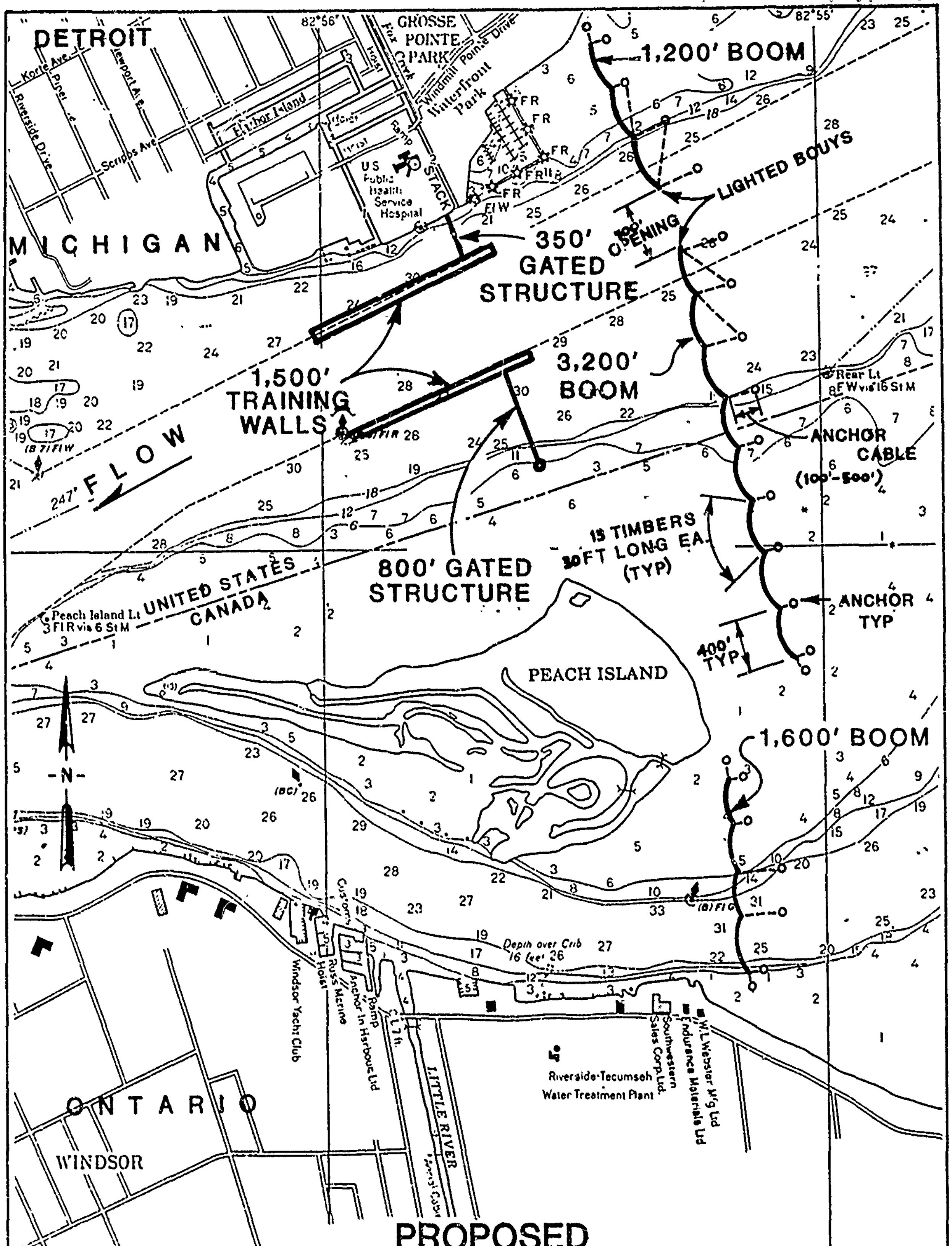
FIGURE B-38



DETAILS OF PROPOSED COMPENSATING WORKS AT STAG ISLAND, ST. CLAIR RIVER

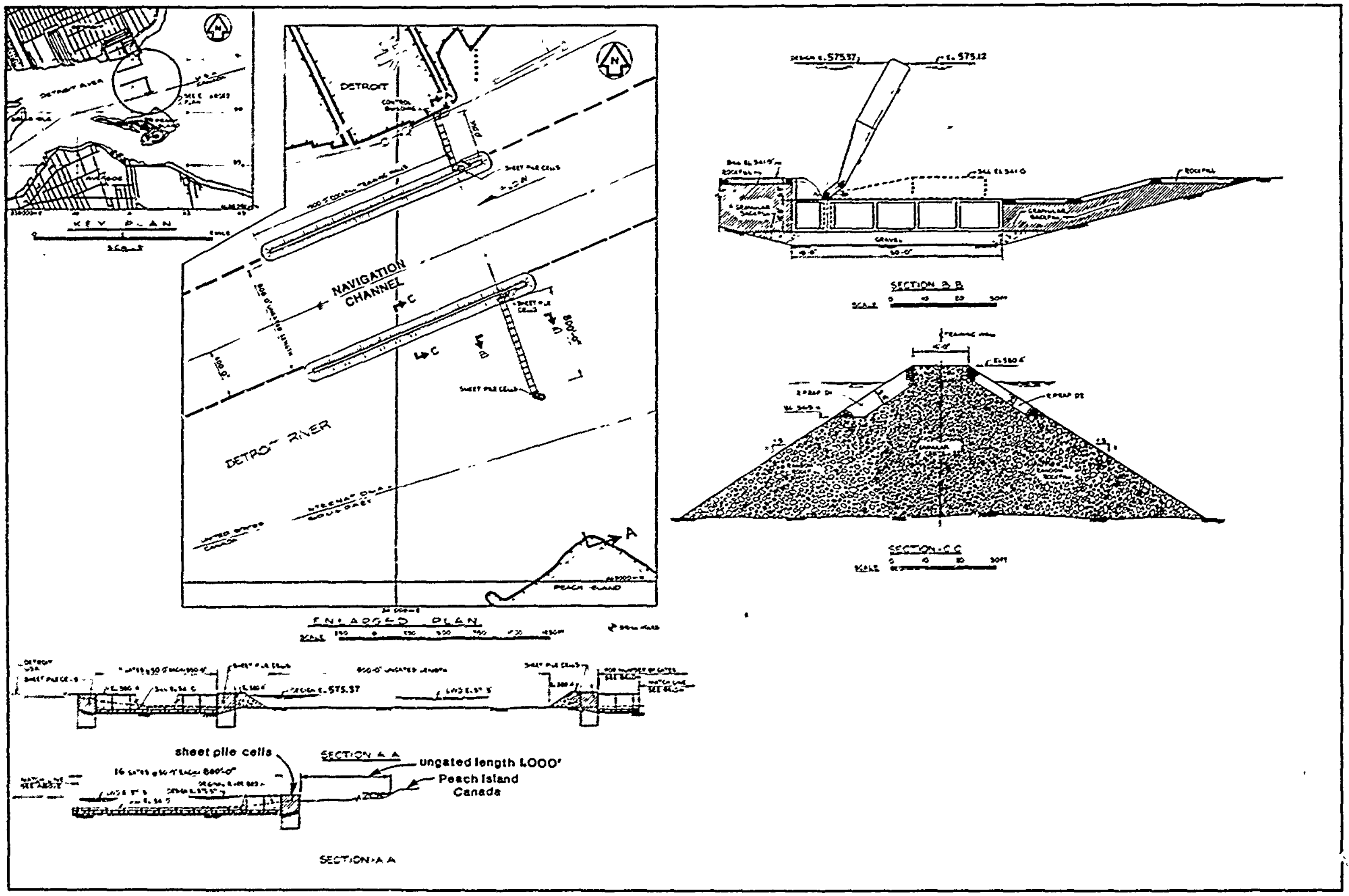
APP B

FIGURE B-39



PROPOSED DETROIT RIVER ICE BOOMS & COMPENSATING WORKS

FIGURE B-40



DETAILS OF PROPOSED COMPENSATING WORKS AT PEACH ISLAND, DETROIT RIVER

FIGURE B-41

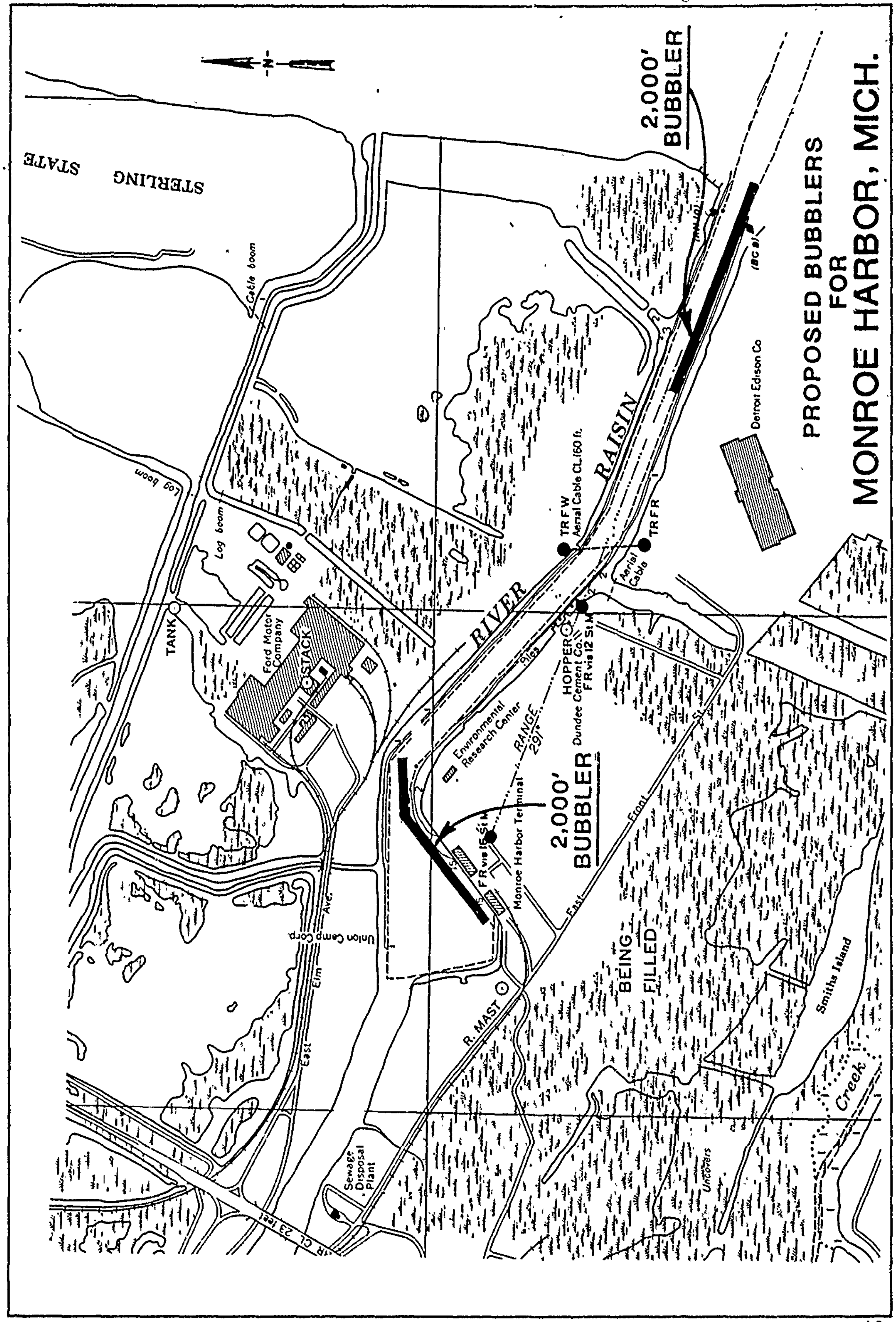

PROPOSED BUBBLERS FOR MONROE HARBOR, MICH.
2,000' BUBBLER
2,000' BUBBLER
RIVER
RAISIN
STERLING STATE
Cable boom
Log boom
Log boom
TANK
Ford Motor Company
STACK
Detroit Edison Co
TRFW
Aerial Cable CL 160 ft.
TRFR
Aerial Cable
HOPPER
Dundee Cement Co.
FR vis 12 St M
Piles
Environmental Research Center
RANGE 291°
Monroe Harbor Terminal
FR vis 15 St M
Union Camp Corp.
East Elm Ave.
East Front St.
BEING FILLED
R. MAST
Smiths Island
Creek
Uncovers
Sewage Disposal Plant

FIGURE B-42

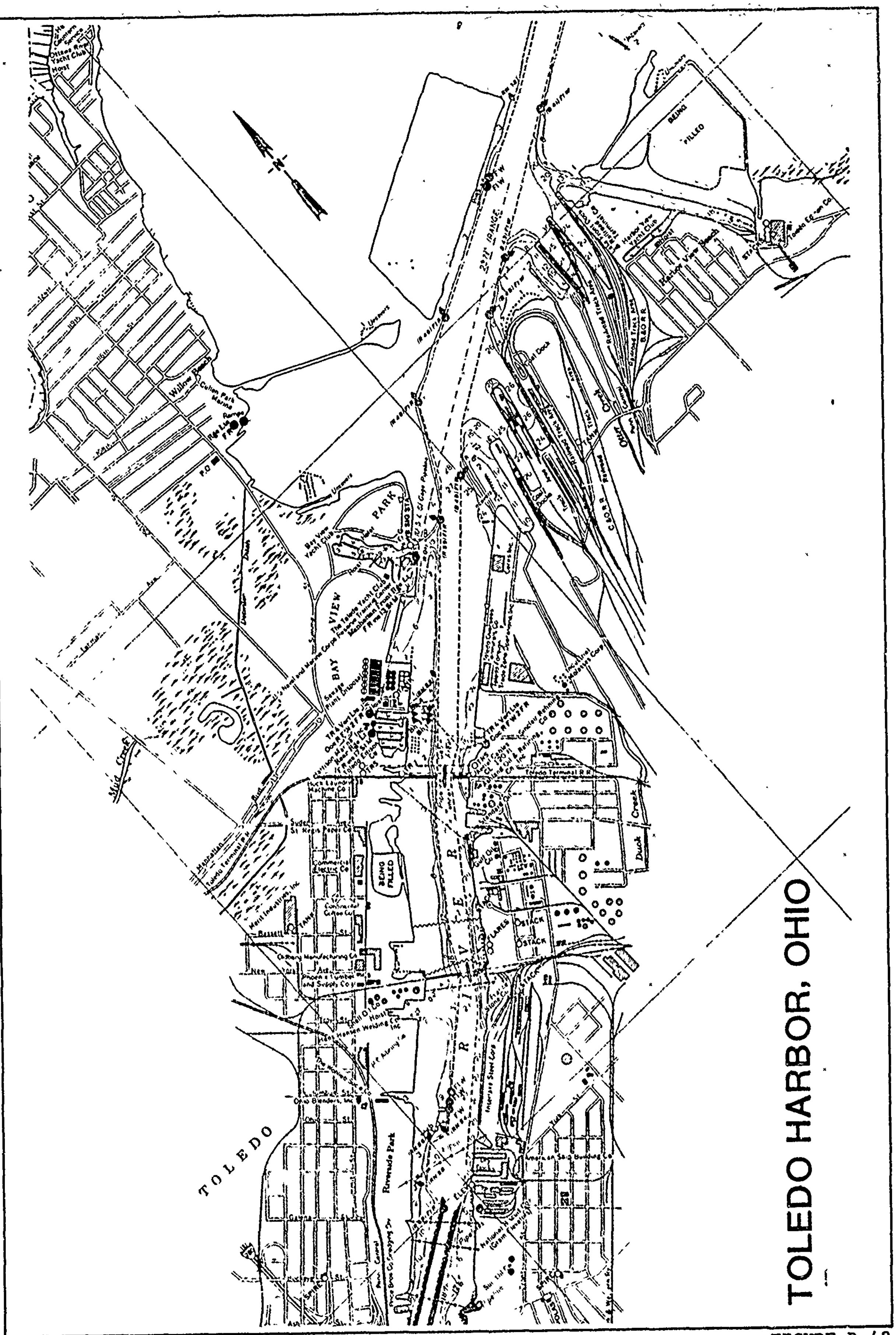

TOLEDO HARBOR, OHIO
TOLEDO
BAY VIEW PARK
Riverside Park
Duck Creek
BEING FILLED

FIGURE B-43

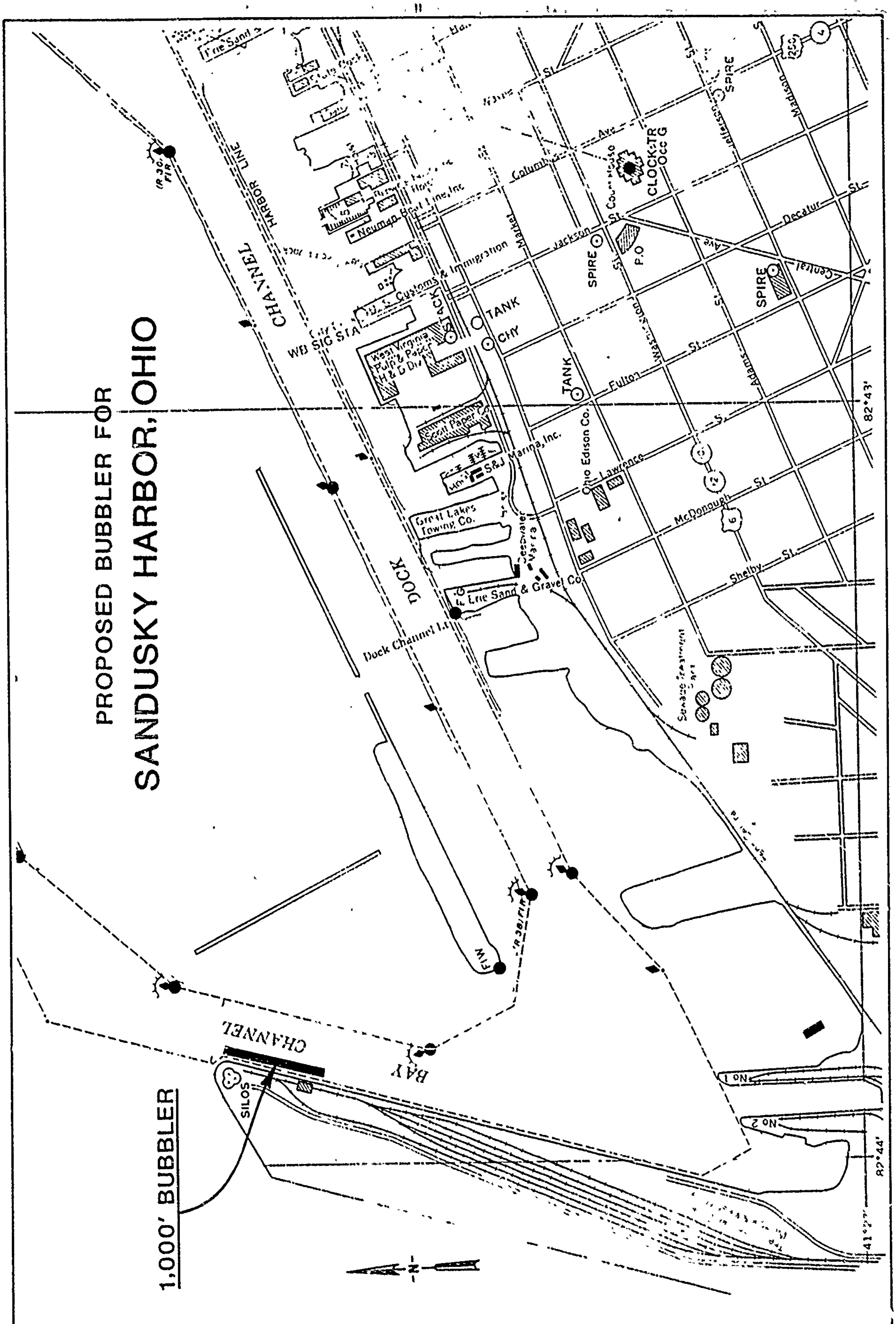

PROPOSED BUBBLER FOR
SANDUSKY HARBOR, OHIO
1,000' BUBBLER
CHANNEL
BAY
SILOS
DOCK
CHANNEL
HARBOR LINE
Dock Channel Lt
Erie Sand & Gravel Co
Great Lakes Towing Co.
S&J Marina, Inc.
Scott Paper
West Virginia Pulp & Paper
U.S. Customs & Immigration
Neuman Boat Line, Inc
TANK
CHY
SPIRE
CLOCK-TR
P.O
Ohio Edison Co.
Columbus Ave
Jackson St
Decatur
Fulton
Lawrence
McDonough
Shelby St
Market
Washington
Jefferson
Adams
Madison
Central
NO 1
NO 2
82°43'
82°44'

FIGURE B-44

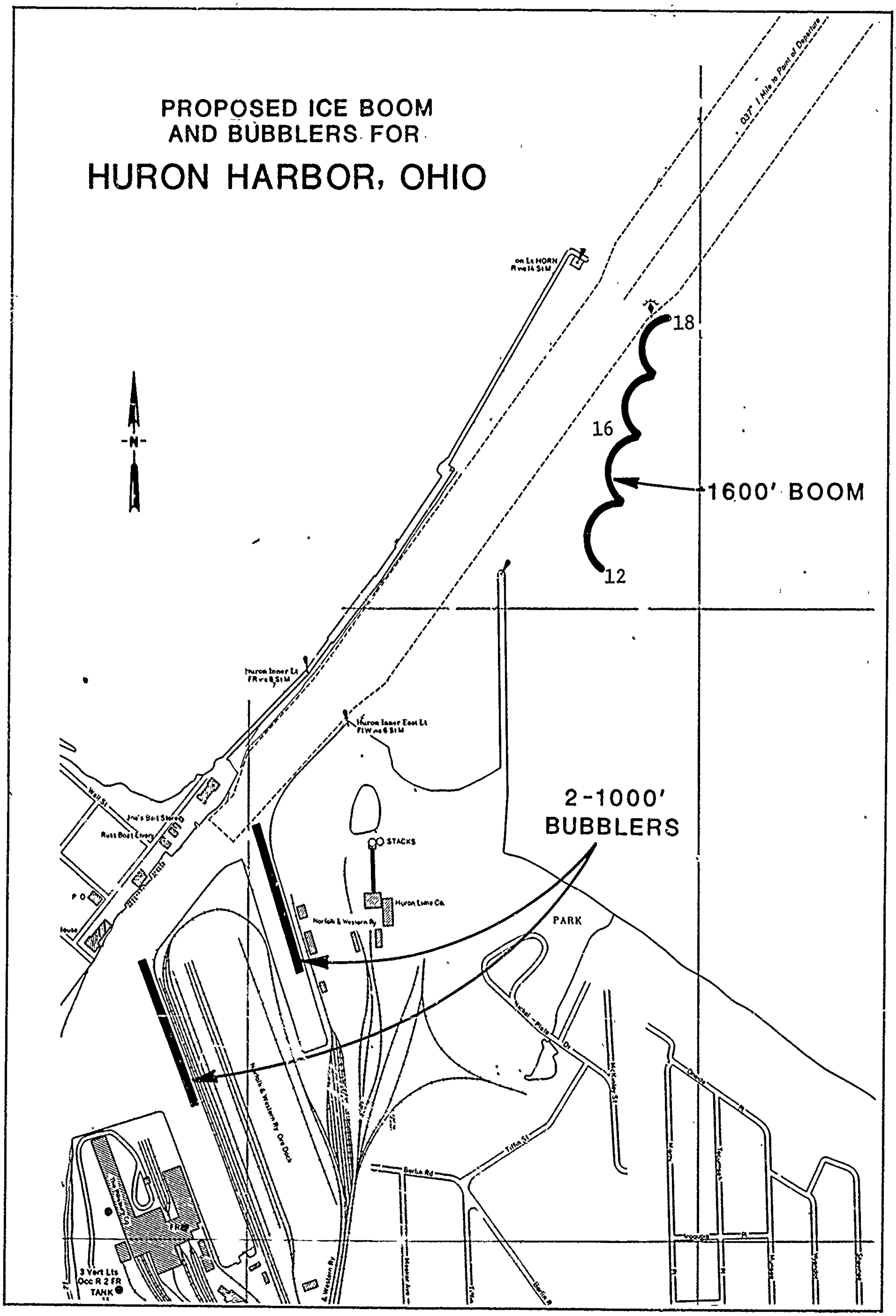

PROPOSED ICE BOOM
AND BUBBLERS FOR
HURON HARBOR, OHIO
-N-
18
16
12
1600' BOOM
2-1000'
BUBBLERS
STACKS
Huron Lime Co.
Norfolk & Western Ry
PARK
Huron Inner Lt
Huron Inner East Lt
3 Vert Lts
Occ R 2 FR
TANK

FIGURE B-45

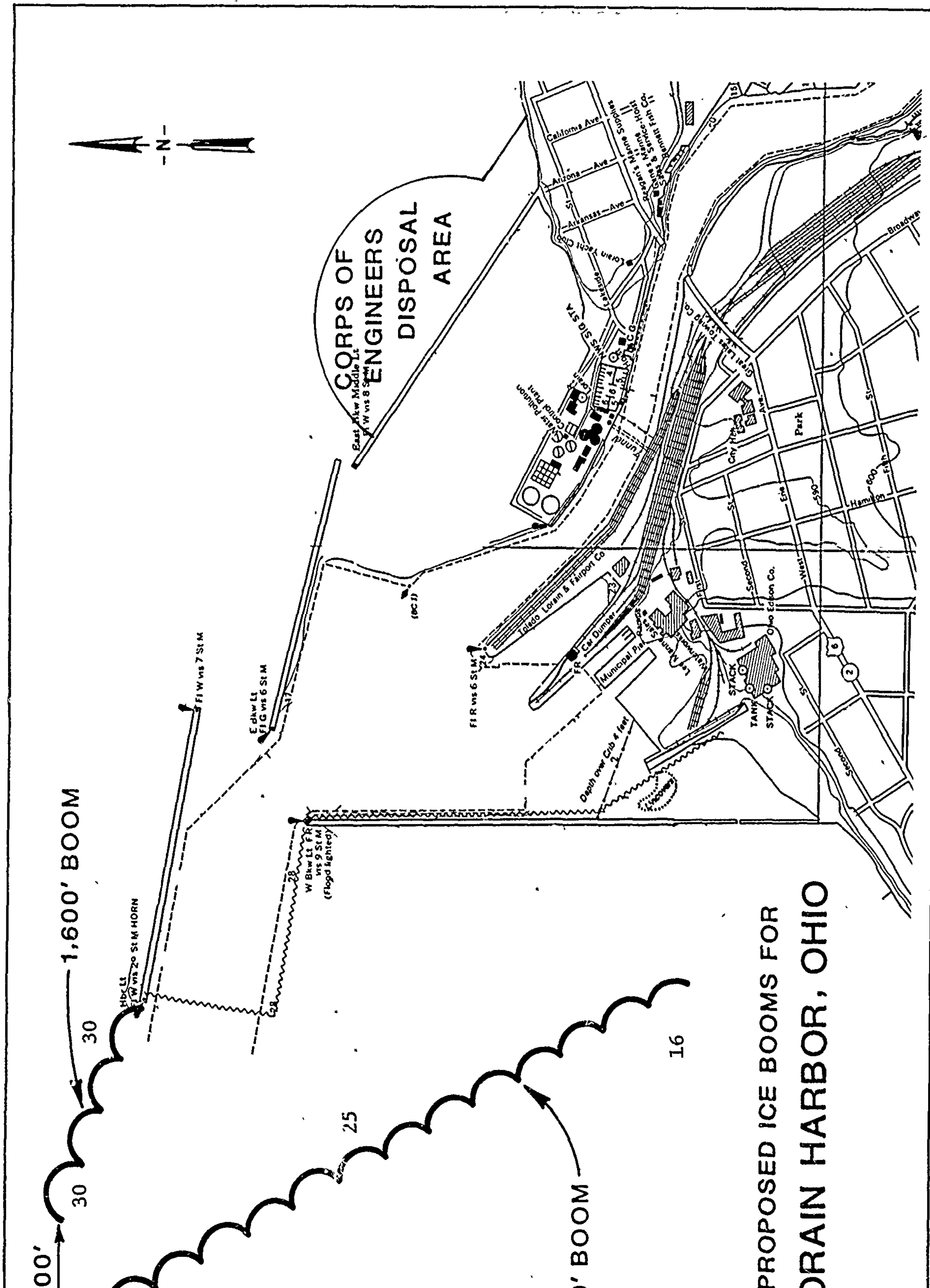
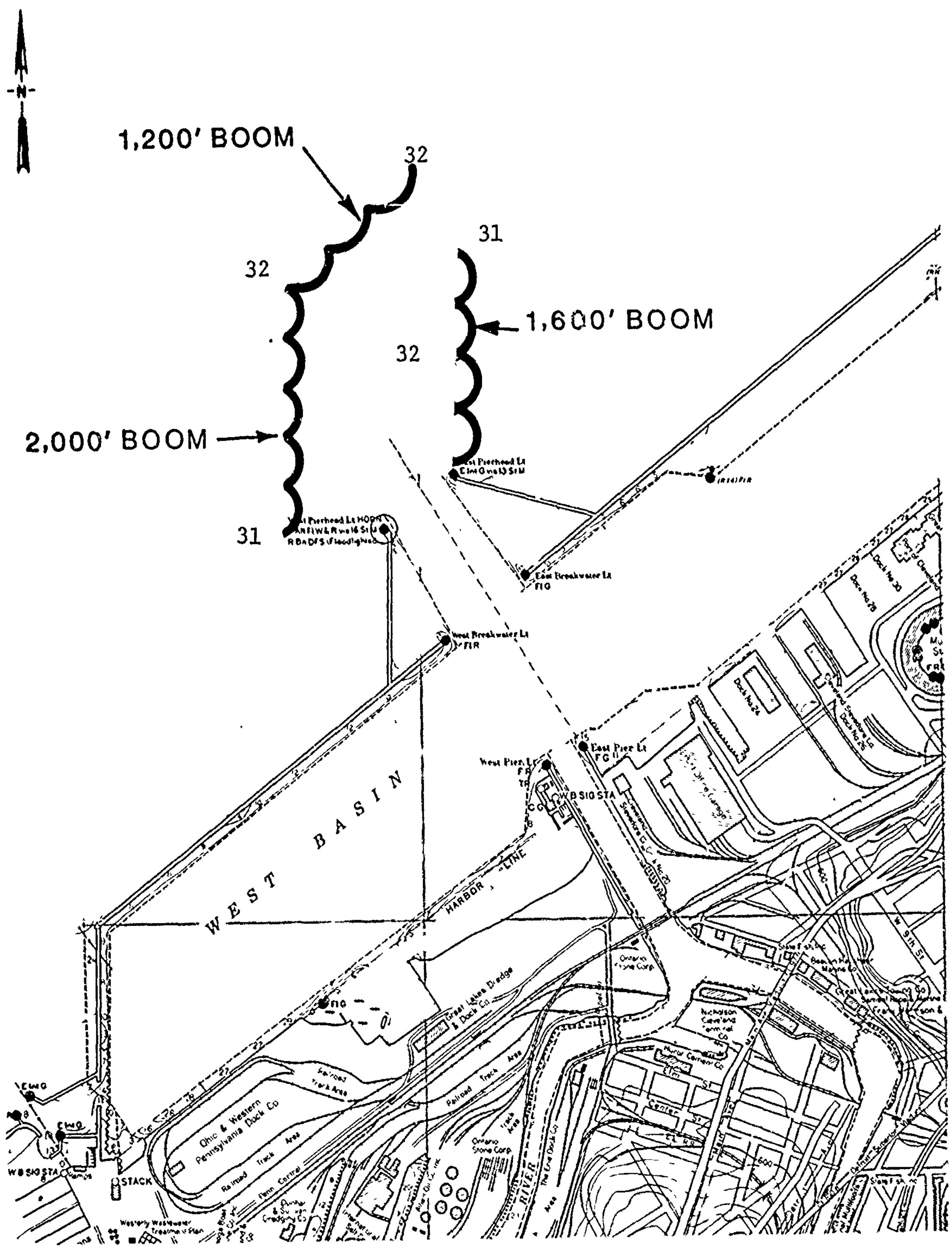

PROPOSED ICE BOOMS FOR
LORAIN HARBOR, OHIO
CORPS OF
ENGINEERS
DISPOSAL
AREA
N
1,600' BOOM
5,200' BOOM
1000'
30
30
30
25
16

FIGURE B-46

PROPOSED ICE BOOMS FOR

CLEVELAND HARBOR, OHIO



APP B

FIGURE B-47

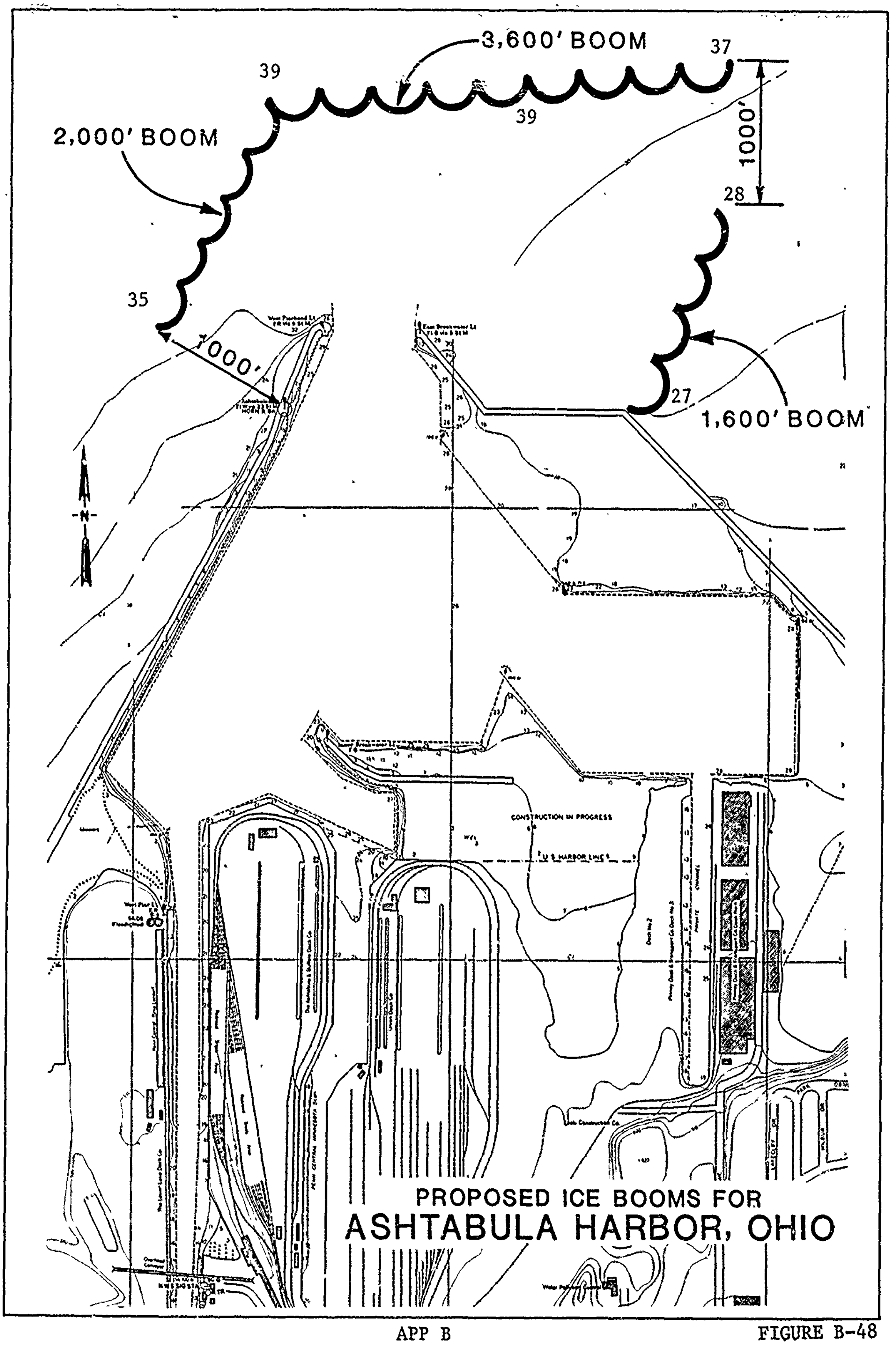

3,600' BOOM
37
39
39
2,000' BOOM
1000'
28
35
1000'
27
1,600' BOOM
N
CONSTRUCTION IN PROGRESS
PROPOSED ICE BOOMS FOR
ASHTABULA HARBOR, OHIO

FIGURE B-48

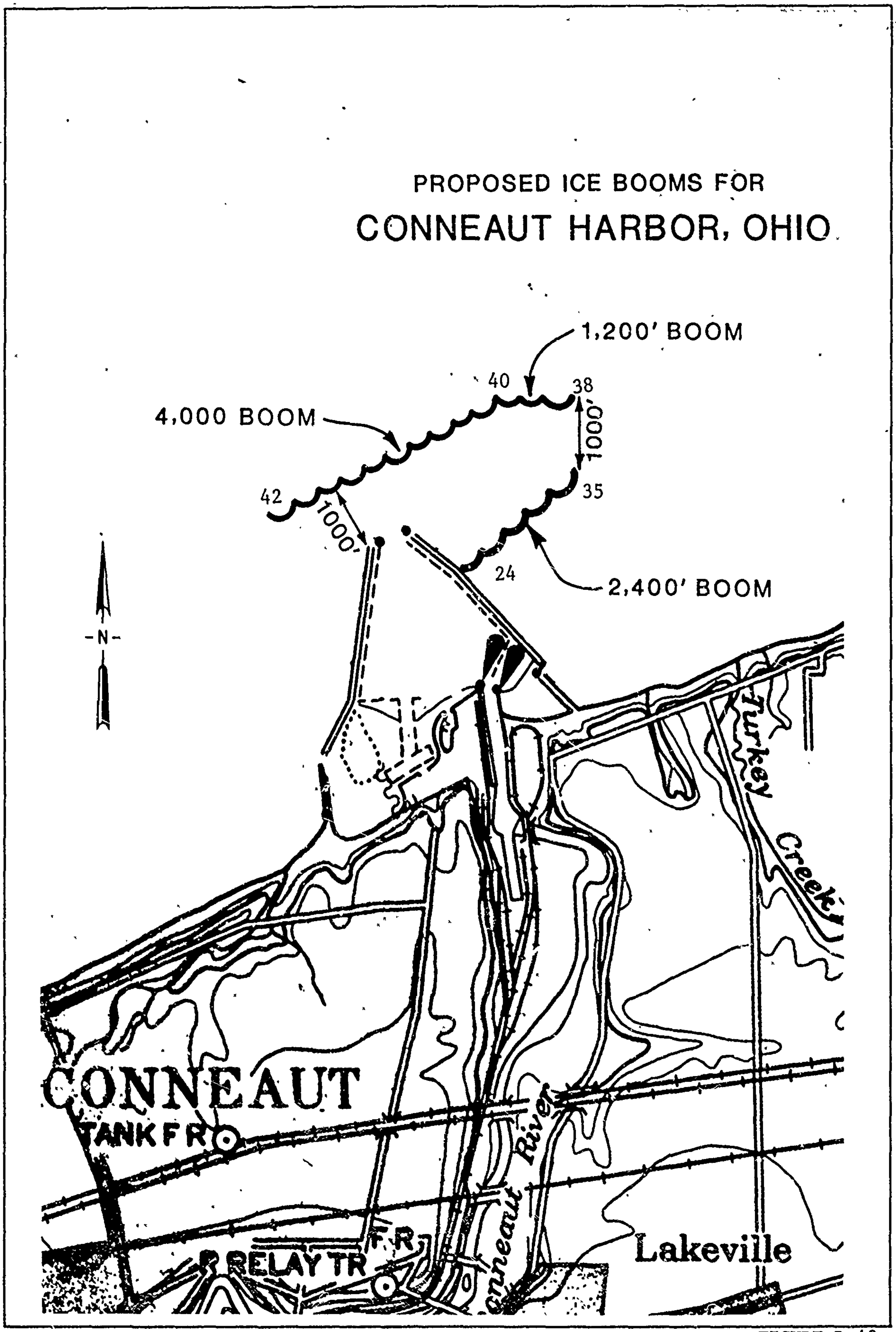
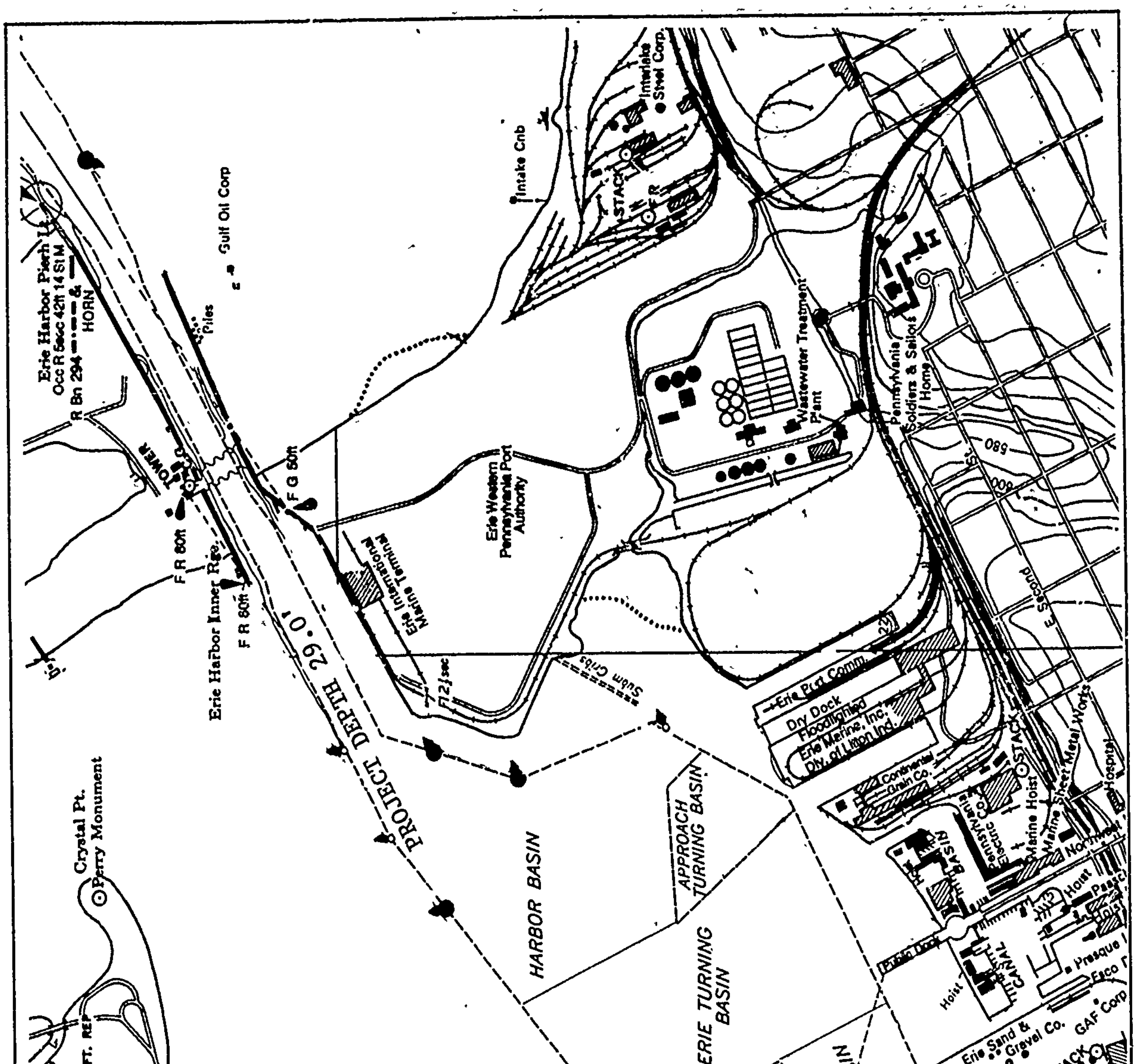
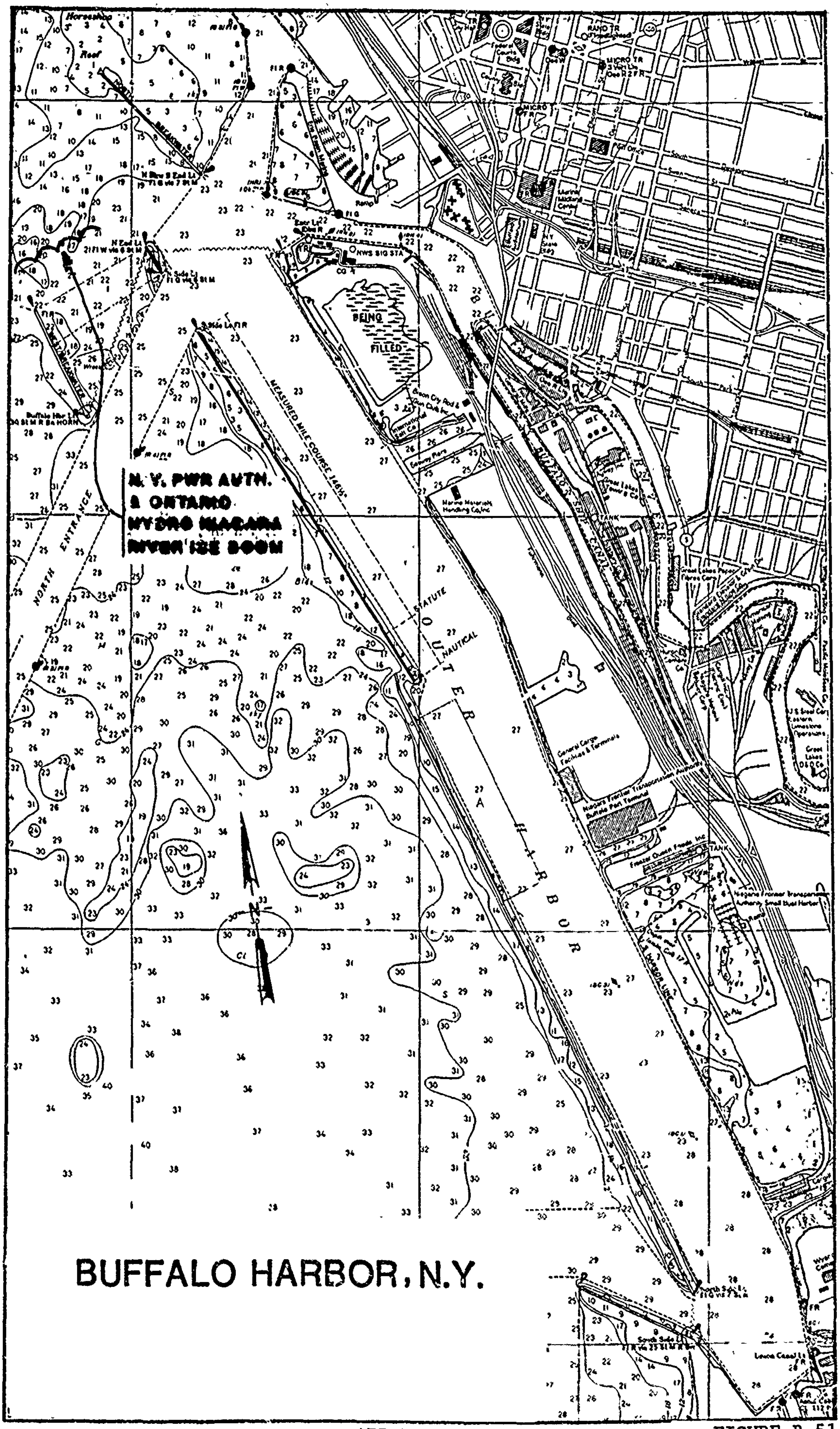

PROPOSED ICE BOOMS FOR
CONNEAUT HARBOR, OHIO
1,200' BOOM
40
38
4,000 BOOM
1000'
42
1000'
35
24
2,400' BOOM
N
Turkey
Creek
CONNEAUT
TANK F R
River
Conneaut
Lakeville
F R
RELAY TR

FIGURE B-49



ERIE HARBOR, PENN.
PRESQUE ISLE
STATE PARK
Public Dock No. 5
Public Dock No. 6
BIG 3
POND
OVHD CAB CL. 45 FT. REP
FIXED BRIDGE VERT. CL. 14 FT. REP
Crystal Pt.
Perry Monument
PROJECT DEPTH 29.0'
HARBOR BASIN
APPROACH TURNING BASIN
ERIE TURNING BASIN
HARBOR TURNING BASIN
Erie Harbor Inner Rge.
F R 80ft
F G 80ft
TOWER
Erie Harbor Pierh Lt
HORN
Piles
Gulf Oil Corp
Intake Crib
Interlake Steel Corp.
STACK
Erie Western Pennsylvania Port Authority
Erie International Marine Terminal
Wastewater Treatment Plant
Pennsylvania Soldiers & Sailors Home
Erie Port Comm.
Dry Dock
Erie Marine, Inc.
Continental Grain Co.
Pennsylvania Electric Co.
Marine Hoist
Hospital
Public Dock
CANAL
BASIN
Hoist
Presque
Erie Sand & Gravel Co.
GAF Corp
E. Second
Drive
East
Fisher

FIGURE B-50



APP B

FIGURE B-51

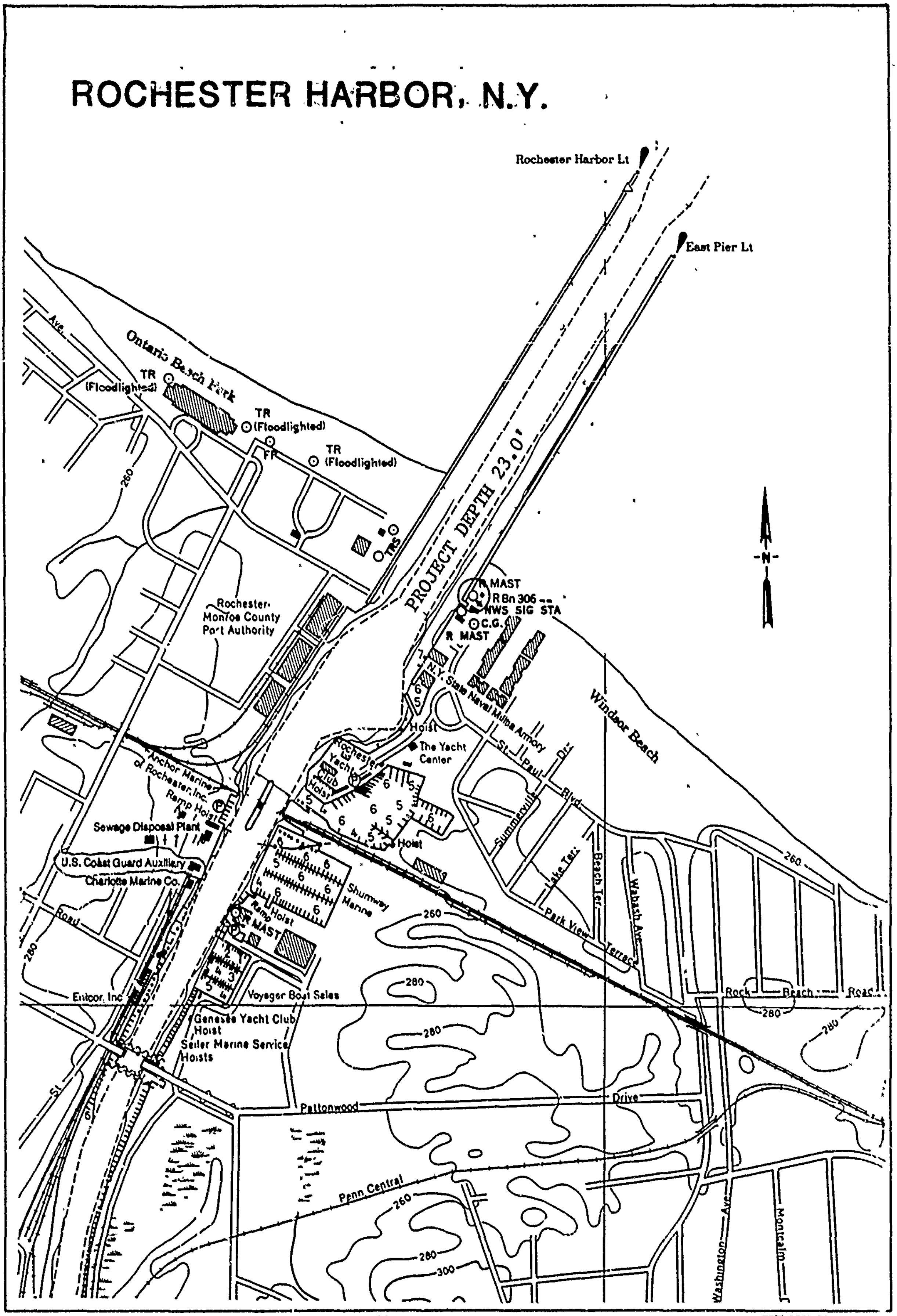
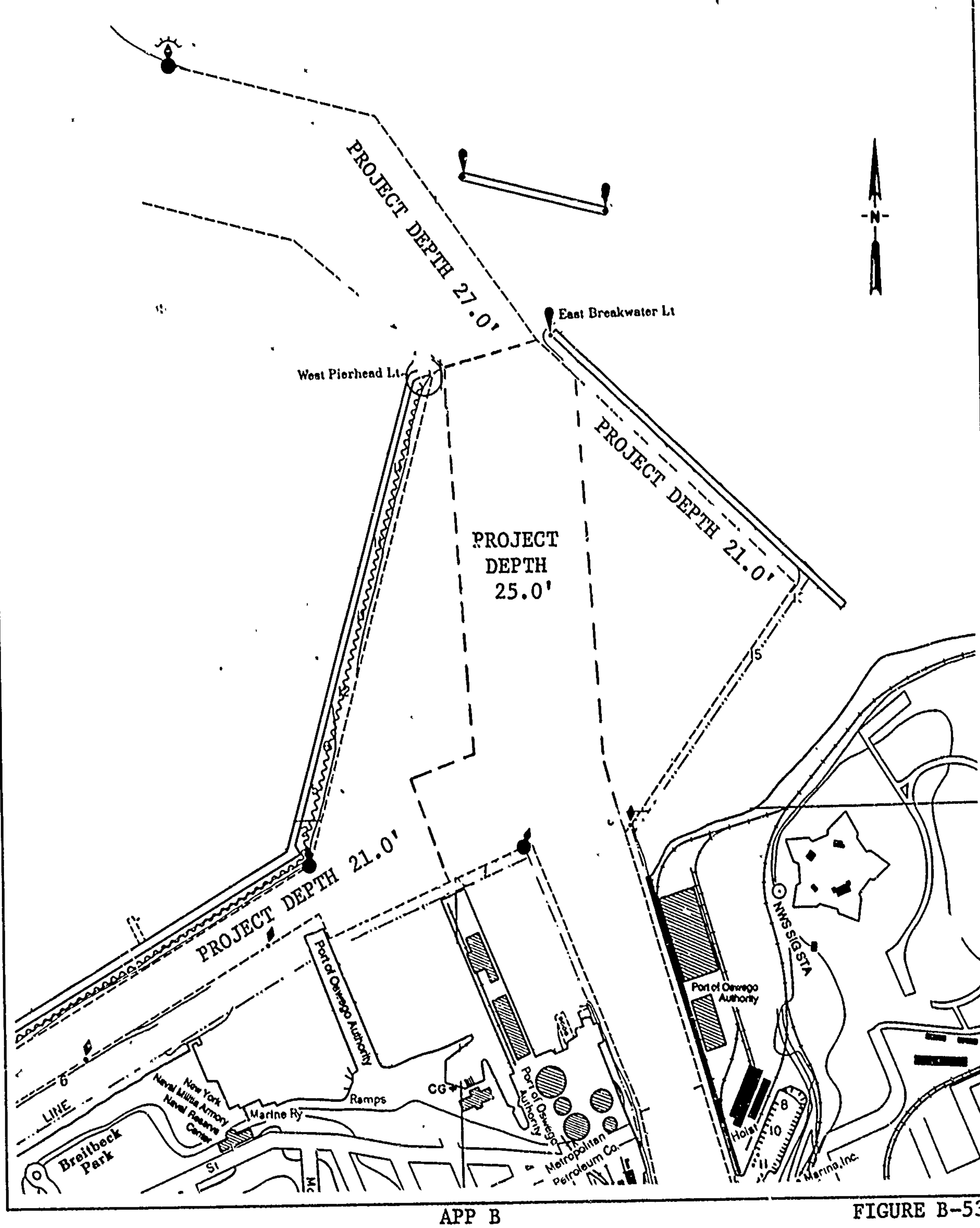

ROCHESTER HARBOR, N.Y.
Rochester Harbor Lt
East Pier Lt
PROJECT DEPTH 23.0'
Ontario Beach Park
TR (Floodlighted)
Rochester-Monroe County Port Authority
R MAST
R Bn 306
NWS SIG STA
C.G.
N.Y. State Naval Militia Armory
Windsor Beach
The Yacht Center
Rochester Yacht Club Hoist
Anchor Marine of Rochester, Inc.
Ramp Hoist
Sewage Disposal Plant
U.S. Coast Guard Auxiliary
Charlotte Marine Co.
Shumway Marine
Voyager Boat Sales
Genesee Yacht Club Hoist
Seiler Marine Service Hoists
Enicor, Inc
St. Paul Blvd
Summerville
Lake Terr
Park View Terrace
Beach Terr
Wabash Ave
Rock Beach Road
Pattonwood Drive
Penn Central
Washington Ave
Montcalm
N

 FIGURE B-52

OSWEGO HARBOR, N.Y.



APP B

FIGURE B-53

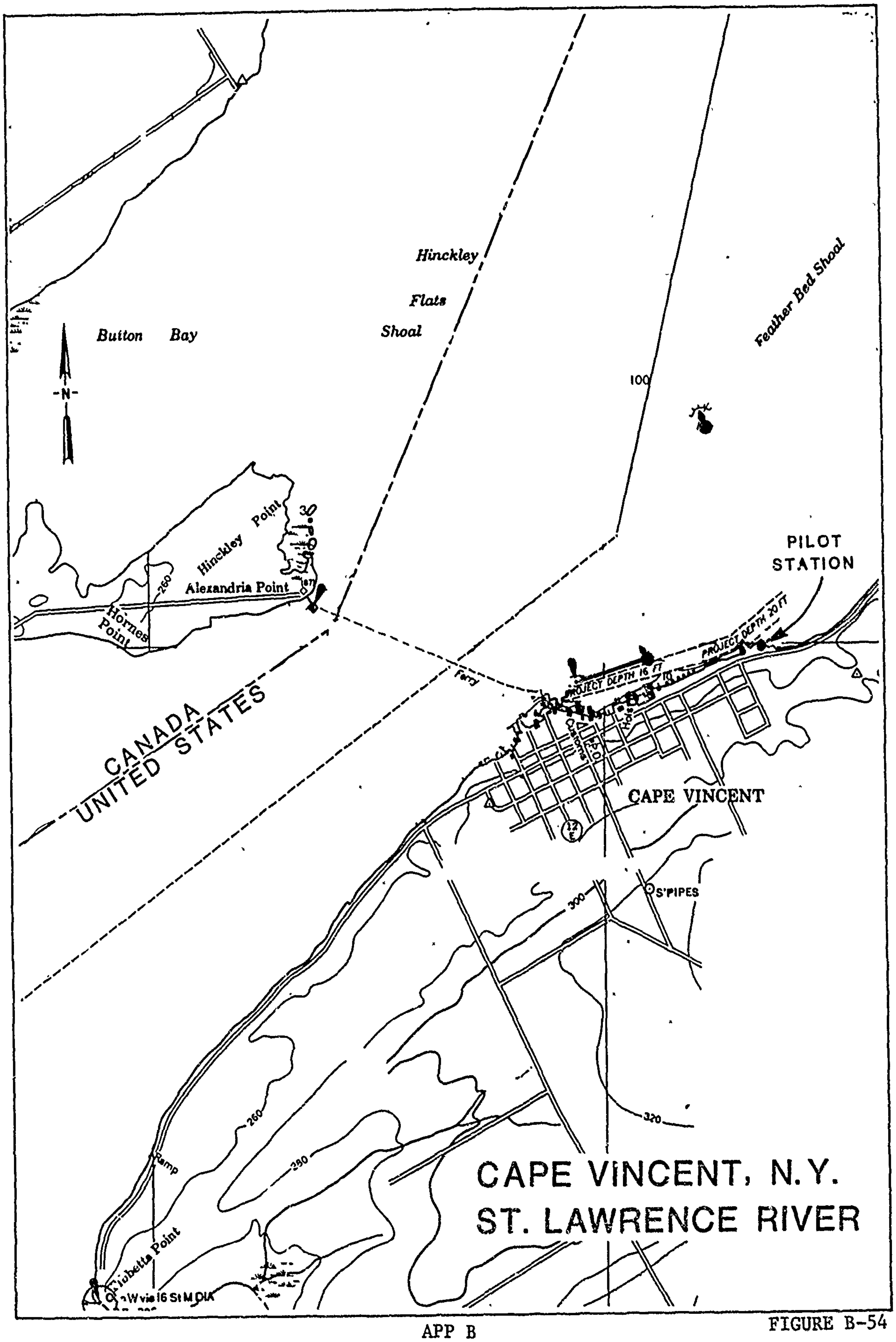
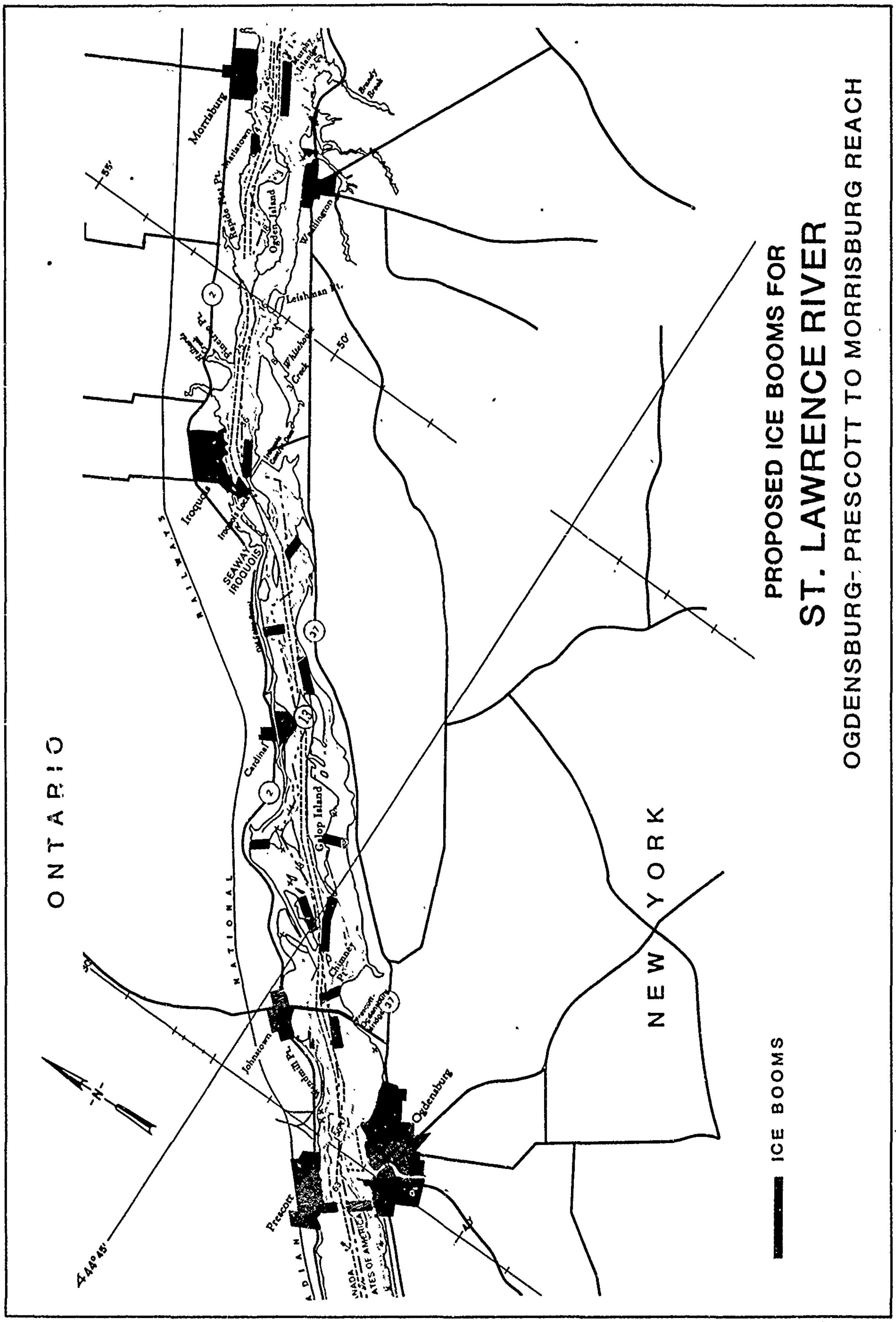

Hinckley
Flats
Shoal
Feather Bed Shoal
Button Bay
N
100
Hinckley Point
Alexandria Point
Hornes Point
260
PILOT
STATION
PROJECT DEPTH 16 FT
PROJECT DEPTH 20 FT
Ferry
CANADA
UNITED STATES
CAPE VINCENT
S'PIPES
300
320
260
280
Ramp
Tiubetts Point
CAPE VINCENT, N.Y.
ST. LAWRENCE RIVER

FIGURE B-54



PROPOSED ICE BOOMS FOR
ST. LAWRENCE RIVER
OGDENSBURG- PRESCOTT TO MORRISBURG REACH

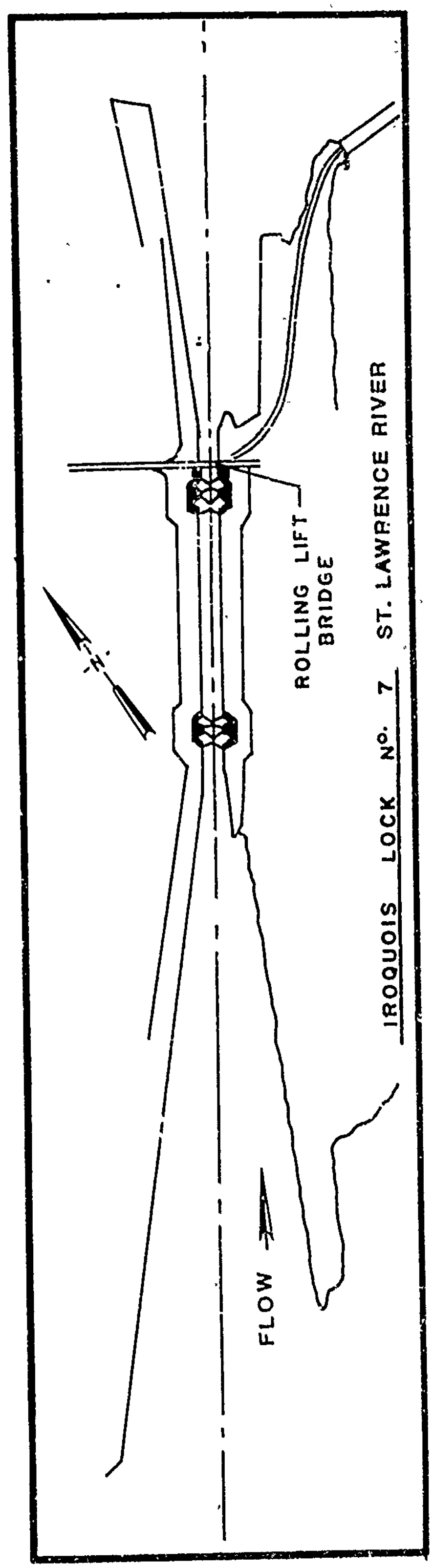

ROLLING LIFT BRIDGE
IROQUOIS LOCK No. 7 ST. LAWRENCE RIVER
FLOW
N

FIGURE B-56

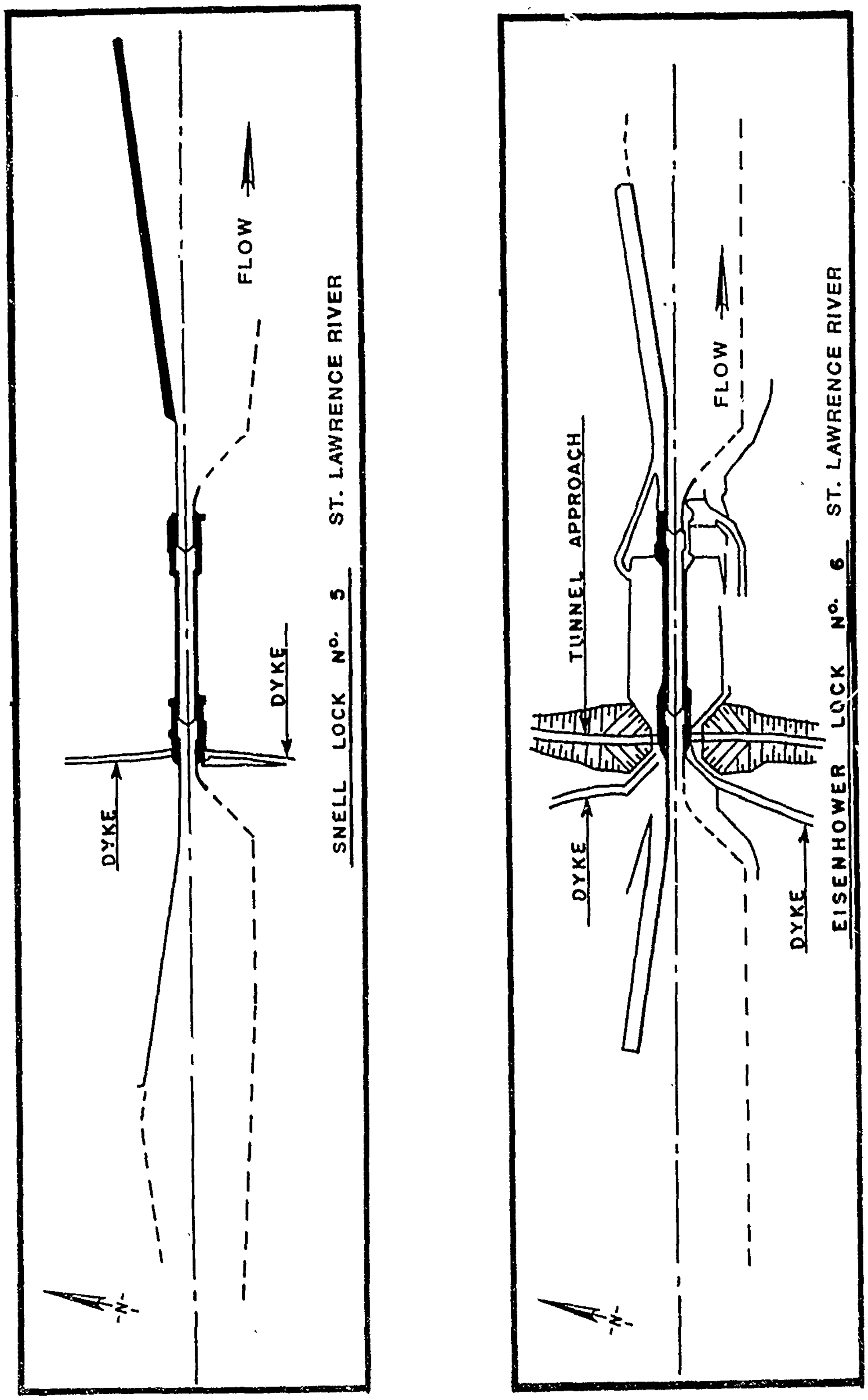
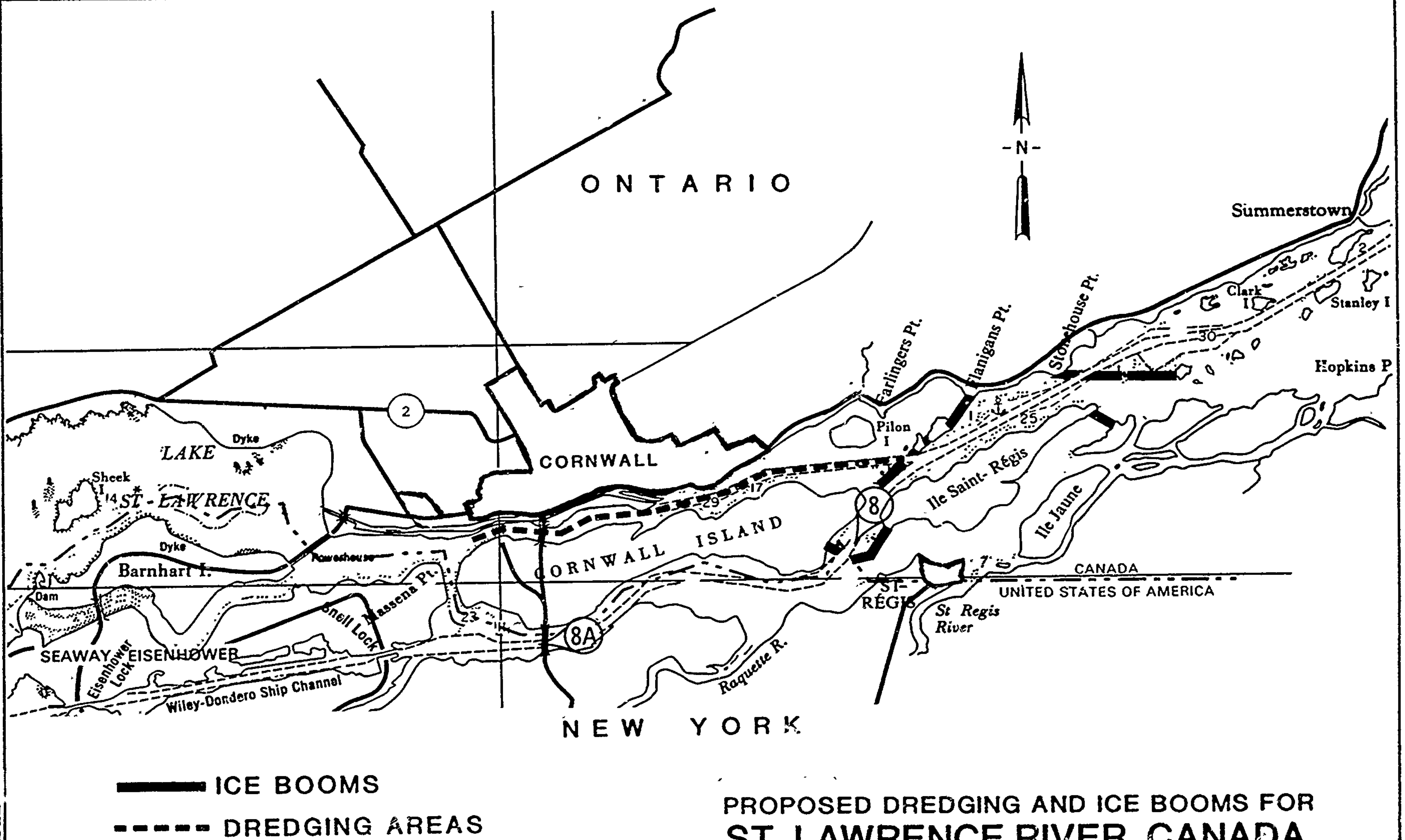

FLOW
DYKE
DYKE
N
SNELL LOCK No. 5 ST. LAWRENCE RIVER
TUNNEL APPROACH
FLOW
DYKE
DYKE
N
EISENHOWER LOCK No. 6 ST. LAWRENCE RIVER

FIGURE B-57



PROPOSED DREDGING AND ICE BOOMS FOR
ST. LAWRENCE RIVER, CANADA
CORNWALL REACH

FIGURE B-58

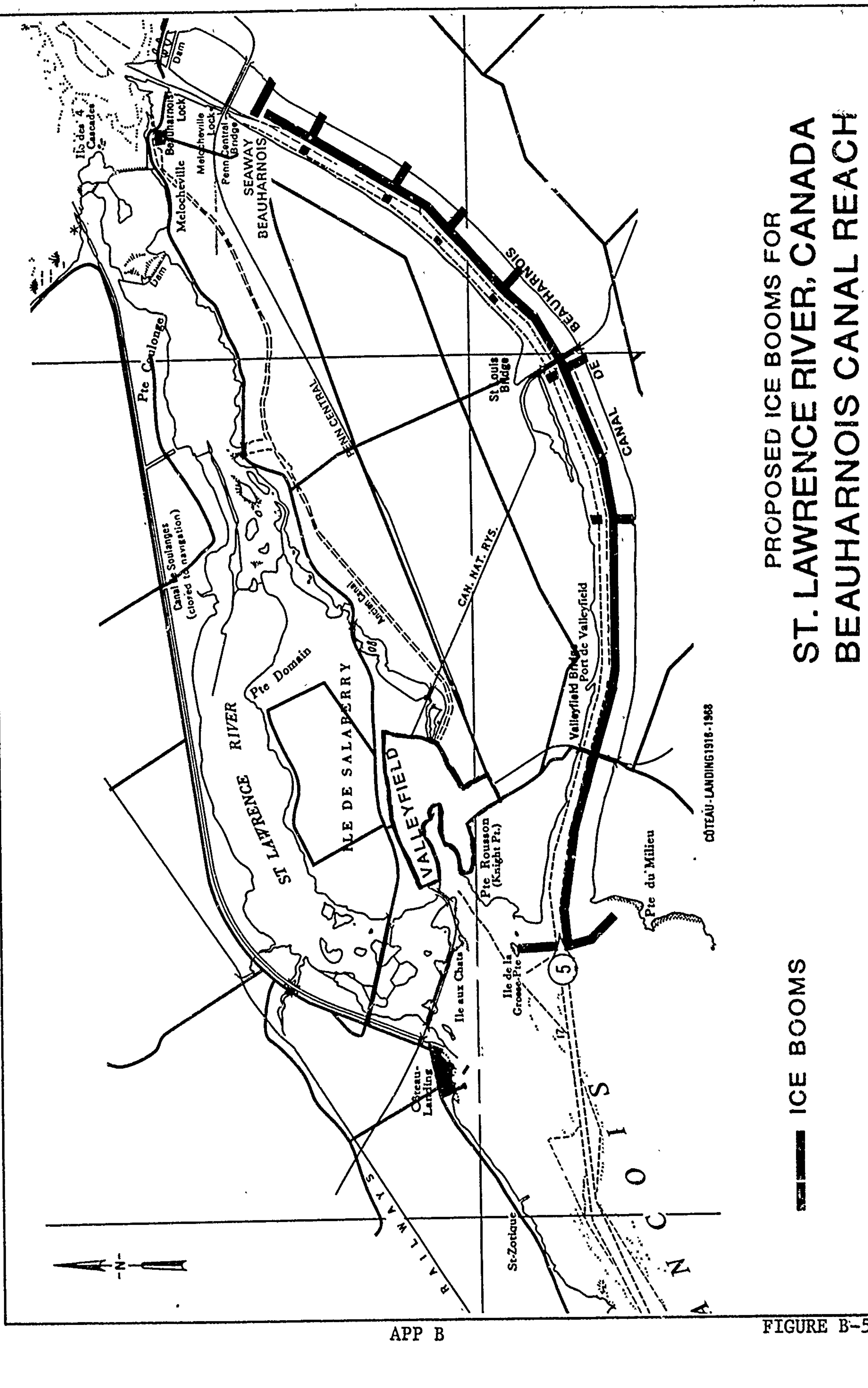
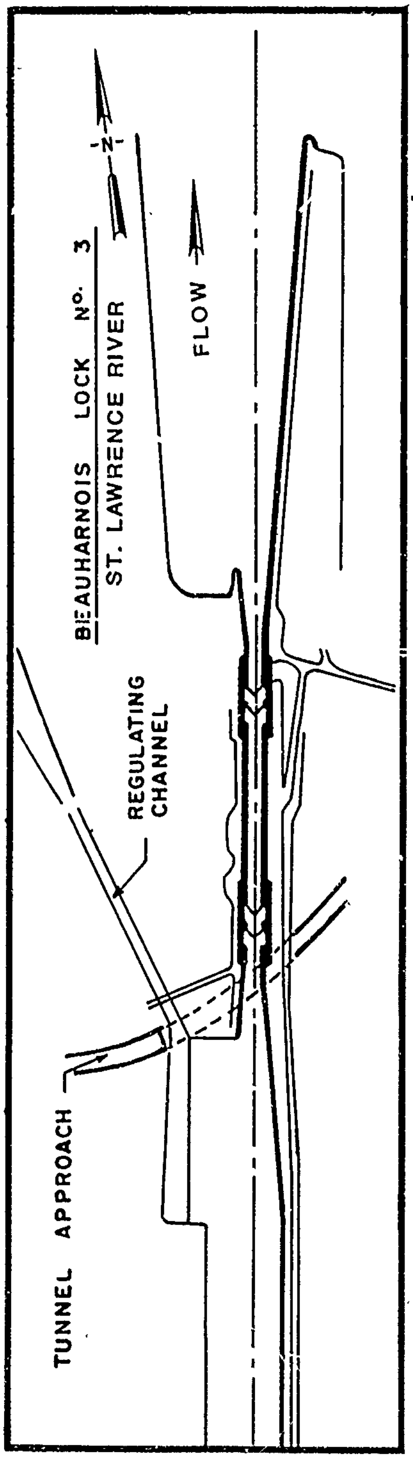
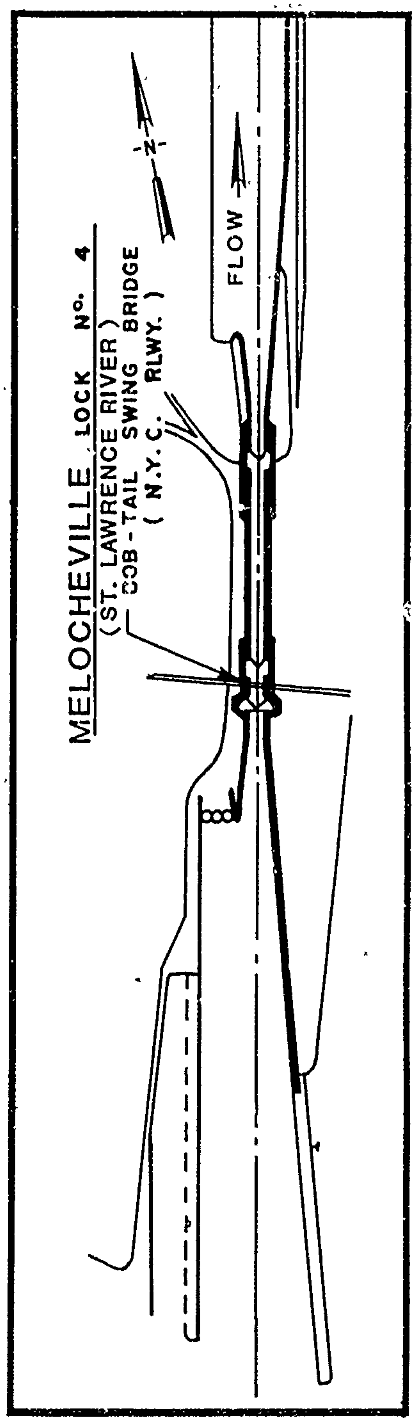

PROPOSED ICE BOOMS FOR
ST. LAWRENCE RIVER, CANADA
BEAUHARNOIS CANAL REACH
ICE BOOMS
ST LAWRENCE RIVER
ILE DE SALABERRY
VALLEYFIELD
CANAL DE BEAUHARNOIS
SEAWAY BEAUHARNOIS
PENN CENTRAL
CAN. NAT. RYS.
RAILWAYS
Canal de Soulanges (closed to navigation)
Pte Coulonge
Pte Domain
Pte Rousson (Knight Pt.)
Pte du Milieu
Ile aux Chats
Ile de la Grosse-Pte
Côteau-Landing
St-Zotique
Valleyfield Bridge
Port de Valleyfield
St Louis Bridge
Penn Central Bridge
Melocheville
Melocheville Locks
Beauharnois Lock
Dam
Ile des 4 Cascades
Ancien Canal
CÔTEAU-LANDING 1918-1968
N

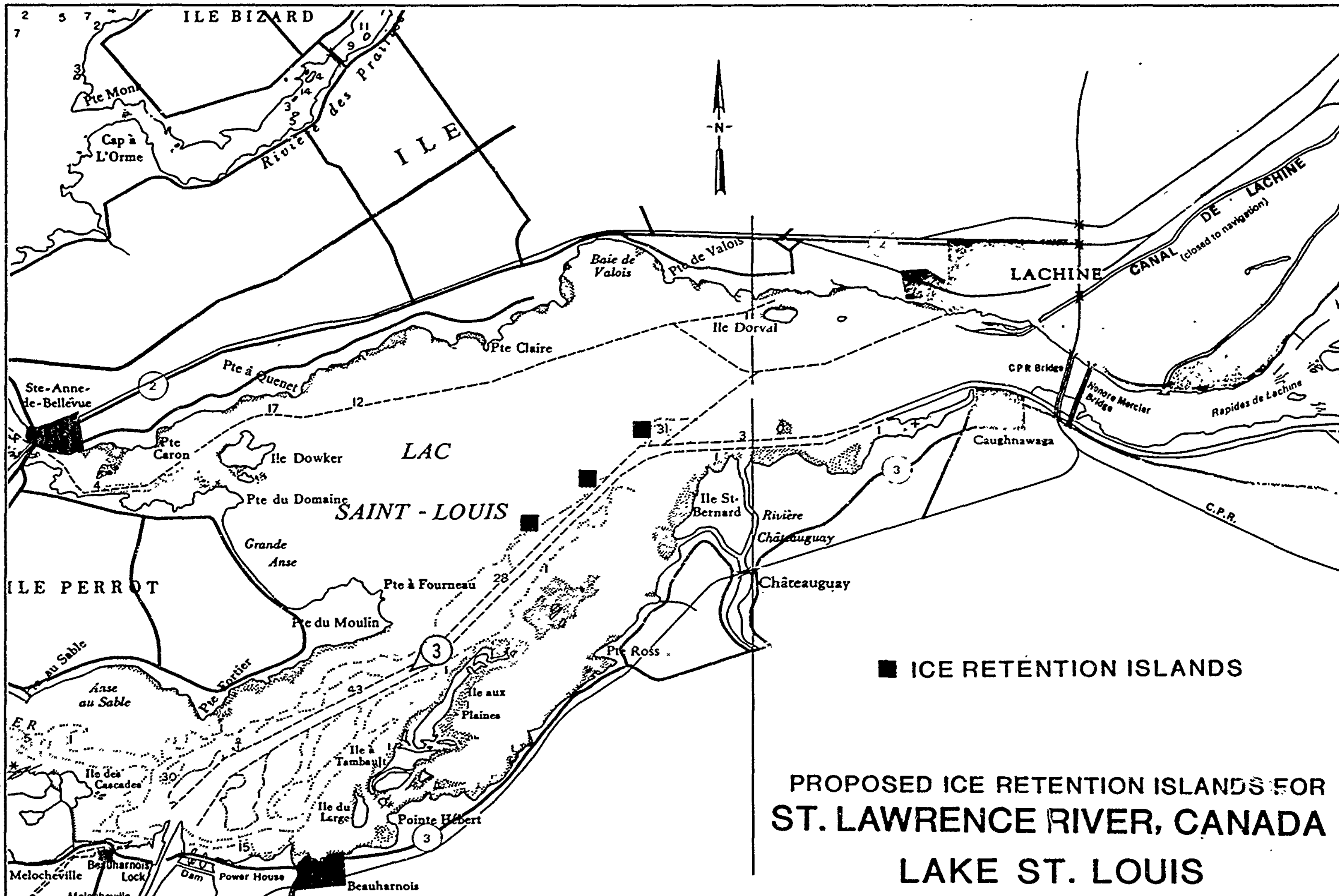
FIGURE B-59





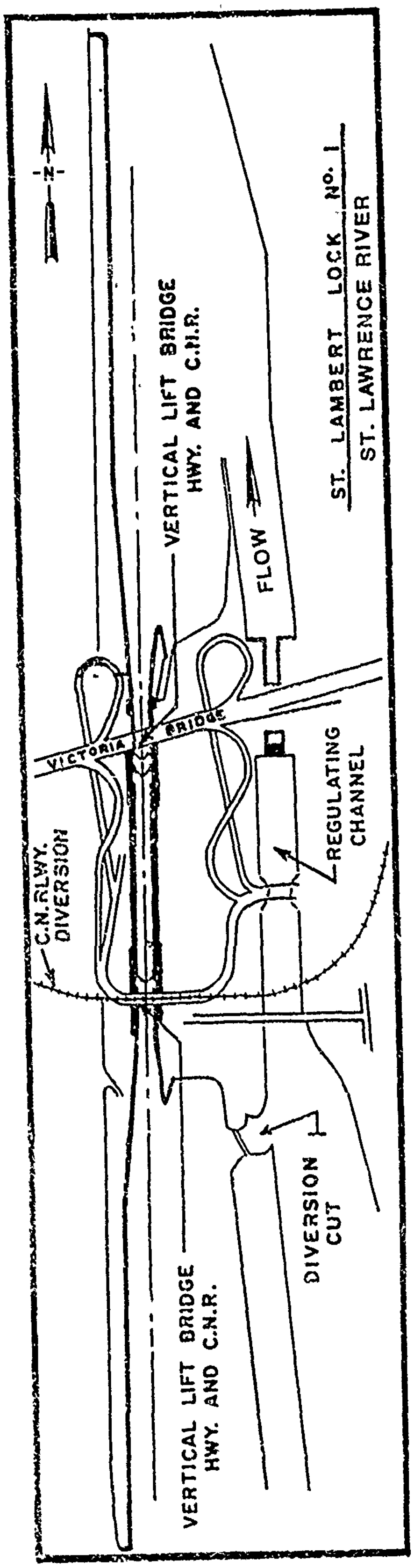
APP B

FIGURE B-60



PROPOSED ICE RETENTION ISLANDS FOR
ST. LAWRENCE RIVER, CANADA
LAKE ST. LOUIS

FIGURE B-61


N
ST. LAMBERT LOCK No. 1
ST. LAWRENCE RIVER
VERTICAL LIFT BRIDGE
HWY. AND C.N.R.
FLOW
VICTORIA BRIDGE
REGULATING CHANNEL
C.N.RLWY. DIVERSION
DIVERSION CUT
VERTICAL LIFT BRIDGE
HWY. AND C.N.R.

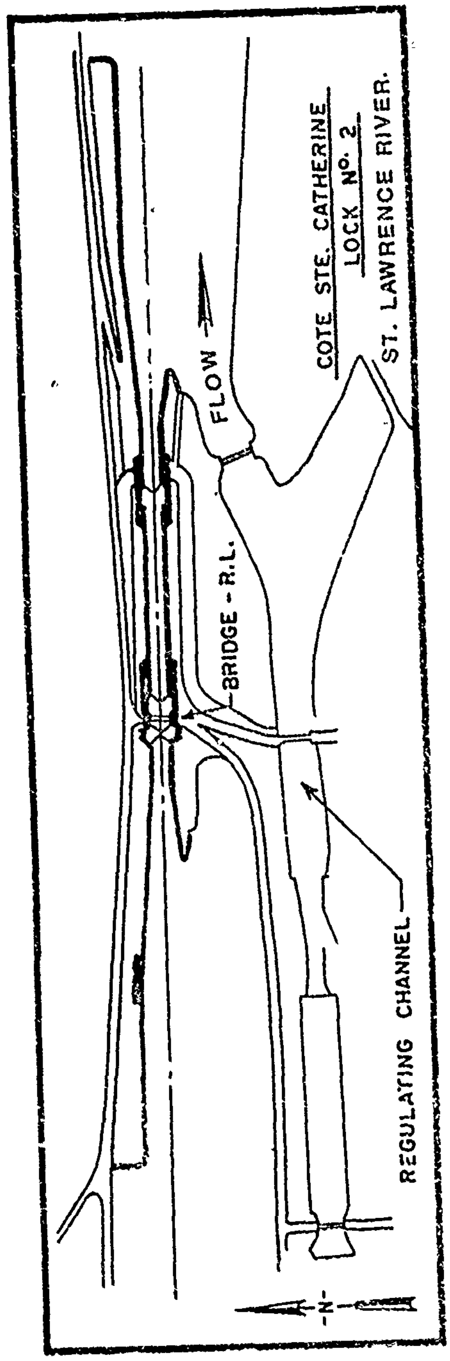
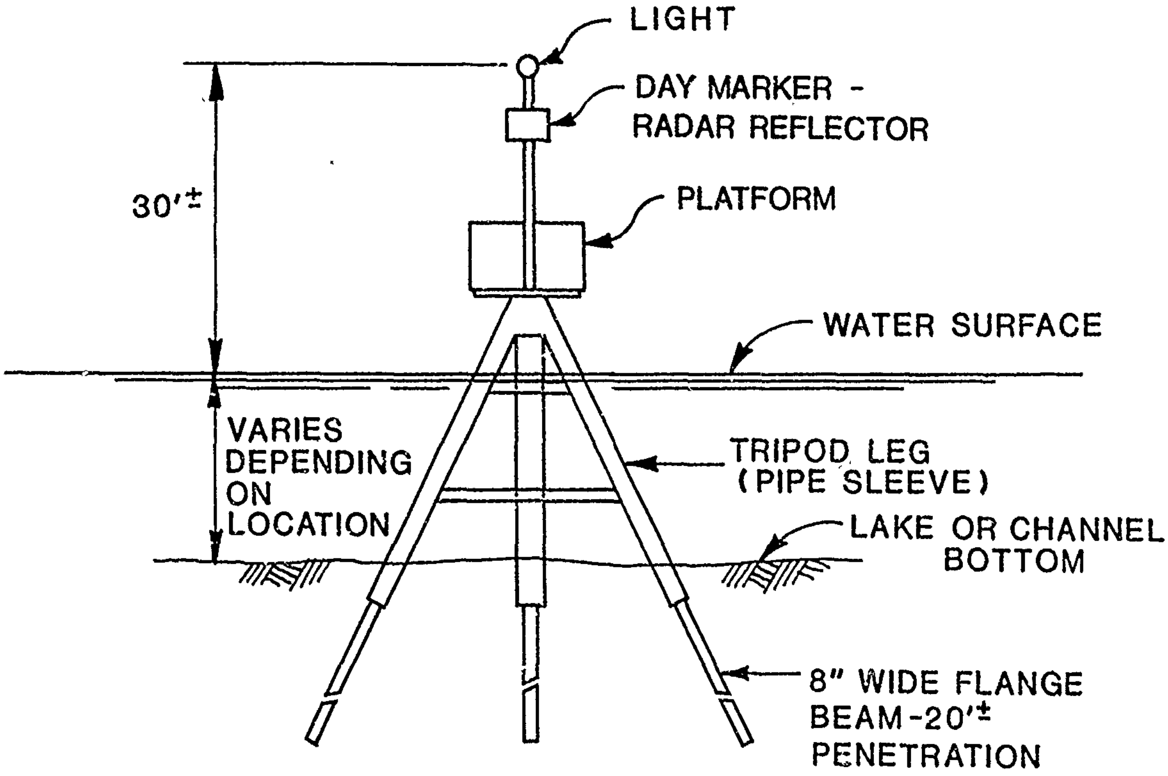

COTE STE. CATHERINE
LOCK No. 2
ST. LAWRENCE RIVER.
FLOW
BRIDGE - R.L.
REGULATING CHANNEL
N

FIGURE B-62



TYPICAL FIXED NAVIGATION
LIGHT STRUCTURE